Quality improvement: Reducing real-time inventory errors through quality control circles

Ting-Chen Hu

Health Business Management Department, Hungkuang University, Taiwan, Republic of China.
E-mail: hutenchen@hotmail.com, htc@sunrise.hk.edu.tw. Tel: 886-4-2631-8652/1275. Fax: 886-4-2652-5850.

Accepted 16 August, 2011

In recent years, with improving living standards in China and people’s enhanced awareness of self-protection, the requirements of medical services have been raised which has seen medical complications such as medication errors rise. To prevent medication errors, hospital pharmacies must improve their technical standards, the service process and the quality of their drug dispensing. Therefore, reducing medication errors and hazards are the sacred duty of every medical worker and pharmacist. According to the medication error occurrence rate defined by the quality control circle (QCC) team, and the priority of the problems that are to be dealt with on the basis of the objective’s beneficial result, feasibility, degree of difficulty and urgency as well as cost, this study applies the seven tools of QCC and the four steps of the Deming cycle (plan-do-check-act, PDCA) to analyze and solve problems systematically.

Key words: Total quality control, quality control circles (QCC), medication errors.

INTRODUCTION

Drug safety as an important issue of health care quality

An adverse drug event is an injury resulting from the use of a drug or when a patient should have been given drugs but does not receive any. An adverse drug event consists of adverse drug reactions, medication errors, side effects and so forth. Adverse drug events have occurred frequently in both inpatients and outpatients early on, but only started to attract people’s attention from the 1990s.

Drugs are special products concerned with life and health. Patients’ drug safety has become a major step to assess healthcare quality in recent years. Currently, the model of medication administration to inpatients in China has improved and this has gradually enhanced the quality of healthcare, but there are still chances of medication error due to incomplete implementation. One sentence in ‘To Err is Human’ published by the Institute of Medicine (IOM) in America reads: “more commonly, errors are caused by faulty systems, processes, and conditions that lead people to make errors or fail to prevent them” (IOM, 1999). The IOM then published patient safety and preventing medication errors, which shows that patient safety and how to prevent medication errors are important indicators of healthcare quality.

The literature indicates that approximately 6.8% of inpatients experience an adverse drug event on average, among which 28% are preventable and 72% are unpreventable. There are 34% preventable adverse drug events which occur in the phase of medication administration under the charge of the nursing staff. Leape and Berwick (2005) research investigates the causes of errors in different phases of using medications (for example, nursing staff injecting vancomycin rapidly can cause low blood pressure in a patient), which can be used as a reference for the improvement of operation systems. Kaushal et al. (2001) analysis is aimed at pediatric medication errors and adverse drug events, and Miller, Brith and Valenti (2006) researched adverse drug events in Australia in 2006. All of these imply that various countries are paying increasing attention to adverse drug events. Pharmacy is one of the major services offered by hospitals, and the quality of its service directly affects the overall image and reputation of the hospital (Hu and Lin, 2011). To prevent medication errors, the most important factor is to enhance the technical standard of the
pharmacy’s service, to improve service procedures and the quality of dispensing drugs. The root causes of medication errors are as follows: firstly, the pharmacy lacks operational norms and a recipe system to follow, or the systems are not strict or complete; secondly, the pharmacy staff do not have solid medical knowledge or high professional skills. Furthermore, the psychological and physical health status of staff, whether they are physically or mentally exhausted or overloaded by work, the work environment should also be considered.

There are a number of specific measures to prevent medication errors. Quality control circles (QCC) activities are those that are taken spontaneously by staff for quality management with principles of self-inspiration, self-improvement and mutual cooperation between team members, which make use of various quality management methods flexibly, promotes staff to continuously participate in improving the management of work that do not meet the quality standard and applies the improved implementation measures to standard operating norms. Hospital administrators must ensure that the staff experience the three stages of participation, involvement and authorization and analyze and improve work procedure actively. Besides, administrators should encourage employees to propose innovative ideas in their specialized areas, make work procedure decisions and practice by the customer-oriented automatic working group. The hospital staff must be involved in the QCC activities, be of one mind and work with collective wisdom and efforts to strive to improve the work procedure, reduce errors, and prevent waste to decrease cost, enhance the quality of service for patients and raise patients’ everyday satisfaction (Yan, 1998).

QCC as an important tool of total quality control

In order to shape the culture of total quality control, an organization should apply some basic methods of quality control and improvement in such aspects as organizational functioning and human resources. QCC is one of the important tools (Lee, 2001). QCC are small groups formed by organizational members based on the similar nature of their jobs, and the group members learn quality education from each other at ordinary times and support each other with real work. Zhong (1995) describes QCC as small groups formed by members who conduct quality control activities spontaneously in the same job site and these groups are one important link of total quality control to continuously improve activities in the job site by the means of all-personnel participation. Therefore, QCC is an organizational activity that practices the idea of total quality control, which can stimulate the potential, improve the constitution of the organization, and achieve the goals of problem solving, continual improvement and customer satisfaction (Hu and Lin, 2001). QCC also provides opportunities for the organizational members to be involved in identifying and analyzing problems, devising solutions and preventing the recurrence of problems, which can make the organization fully utilize human resources accurately, quickly solve problems and effectively stimulate members’ awareness of quality; thus, the organization’s products and service quality will be greatly improved (Lee, 1995).

MATERIALS AND METHODS

Research framework

This study adopts a case study method and extensively discusses the process of promoting QCC by the hospital pharmacy in this case and other related issues. The collection of case materials focuses on the hospital, and is aimed at the pharmacy department’s conducting of QCC activities. The following items are introduced in several stages of QCC activities, its operation process, implementation and fulfillment, discussion of the benefit, and the key factors to success.

Subject designation

In this case, the hospital’s pharmacy department forms a QCC to improve the department’s work. A discussion of all the circle members reveals that the quality of drug dispensing covers extensive categories, including management issues such as accuracy rate, speed and cost. Therefore, taking explicitness and measurableness into consideration, the theme of QCC activities is set to be reducing the occurrence rate of medication errors.

Problem diagnosis

Data collection results show that there were 85 errors in the whole of 2007, 27 errors in 2008, and 11 errors before the QCC activity (2009/10/23). The figure is zero during the period of collecting data by the QCC. After all QCC members’ discussion, it is discovered that medication preparation work in the drug dispensing process of the pharmacy department has improved before QCC activities. The original schedule is that one pharmacist prepares the medication and the dispensing pharmacist checks it, which has been changed into a system in which two pharmacists are in a group, one charging with preparing and the other with checking. Therefore, the implementation of this strategy has not avoided any error. For this reason, in the QCC activity on November 14, through discussion and negotiation, the deputy director of the pharmacy department and all members of QCC decided to choose “real-time inventory”, which is supposed to be carried out in full operation in December, as the theme of improvement to increase the accuracy rate of the inpatient pharmacy inventory. However, the time left for closing the case is less than one month. Besides, real-time inventory is not carried out in full operation at the very beginning, which only conducts 66 kinds of precious drugs in the inpatient pharmacy. In addition, those drugs are checked everyday, so the error occurrence rate is very low. Due to the time limit, the 10 improvement stages of QCC cannot be followed; therefore, the activity pattern has to be changed to process diagnosis.

Process pattern

Diagnosis and analysis of real-time inventory problems

Implementation of the real-time inventory is to ensure medications are correctly used and stored, expecting to reduce medicine
contamination and waste as well as dispensing errors. But its implementation should first guarantee the stability of the system, and then the checking results can actually show the aim of the real-time inventory. This diagnosis process is as shown in Figure 2.

1) System stability analysis: In the first stage, a real-time inventory record of 66 drugs listed by the pharmacy for inpatients was made, and eight days of data from November 30 to December 7 shows that the average of errors per day was 20.875. The number of errors per day is shown in Figure 3. Suppose that the number of errors per day is plus or minus 50, then, this is due to systematic errors. Therefore, according to the assumption, the statistic of systematic errors per day is as shown in Figure 4.

Moreover, the rate of systematic errors in Figure 5 shows that the system seems to be unstable and shows an upward tendency. If deducting the systematic errors, the average daily errors are 16.25 according to the data collected in eight days. The number of daily errors is as shown in Figure 6. The data in Figure 7 shows that the number of daily errors is 20.875 with 4.625 systematic errors and 16.25 real errors.

2) Analysis of differences of the real-time inventory: The data in hand is that of eight days in total from November 30 to December 7. There are 130 errors in total, deducting the systematic errors, with an average of 16.25 errors per day. The 130 repeated items can be divided into 42 items. Figure 8 divides the 42 items into oral drugs, injections, and tablets according to the types of drugs by way of
stratification. Items of different types are shown in the following graph, from which we can see that the share of tablets is the biggest. Through analysis of the 130 items, we find that the most errors take place over three consecutive days, followed by those
Figure 6. The number of errors deducting systematic errors.

Figure 7. The number of various errors.

Figure 8. The number of various error items.

Analysis in accordance of drug types by way of stratification is shown in Figure 10. The more days of errors represents a higher probability of abnormality. There are 26 drugs in total with errors for three, four, five and six consecutive days. The names and types of drug errors are listed, and causes of errors are found out after the investigation of the inpatient pharmacy supervisors. Data is shown in Table 1. “Information” in the table represents errors in the information system database field or errors caused by not merging the data. “Delivery” represents drug storage workers have not input...
the information to the system after dispensing the drugs so that drugs brought in have not been added to the inventory, while drugs in the inpatient pharmacy have been dispensed to the inpatient area (treatments cannot wait). As a result, errors occur when checking. “Self-checking error” represents errors committed by the inpatient pharmacy workers during checking.

It can be seen in Figure 11 that among the 26 errors, 15 are caused by delivery; 9 are caused by information; and the least occur in self-checking. Therefore, errors caused by external reasons (information or delivery) take up 92.31% of all the errors, which should be the first to be resolved.

RESULTS

After realizing the causes for the discrepancies of the real-time inventory in the hospital pharmacy, QCC immediately conducted a series of work such as communication, coordination, self-criticism and improvement based on the causes. The ongoing order is: 1) to enhance the stability of the real-time inventory’s information system; 2) to confirm the accuracy of the information system’s operation staff; 3) to establish standardized instructions for medicine management procedures in the inpatient pharmacy.

Enhance the stability of the real-time inventory’s information system

Through close communication and discussion between the inpatient pharmacy supervisor and the information section, the stability of the current real-time inventory information system has been greatly improved as shown in Figure 12. Therefore, the instability of the system can be excluded from causing the checking errors.

Confirm the accuracy of the information system’s operating staff

After analyzing such problems, the inpatient pharmacy supervisor discovered that drug storage workers may not input the information of drugs dispensed into the

---

**Figure 9.** Days of continuous errors.

**Figure 10.** Days of continuous errors of different items.
Table 1. Causes of medication errors.

<table>
<thead>
<tr>
<th>No.</th>
<th>Drug names</th>
<th>Days of the errors</th>
<th>Types of drug</th>
<th>Cause of errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Capecitabine Tablets</td>
<td>3</td>
<td>Tablet</td>
<td>Information</td>
</tr>
<tr>
<td>2</td>
<td>Levofoxacin Tablets (Cravit)</td>
<td>3</td>
<td>Tablet</td>
<td>Information</td>
</tr>
<tr>
<td>3</td>
<td>Doxazosin Mesylate Controlled Release Tablets (Cardura XL)</td>
<td>3</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>4</td>
<td>Donepezil Hydrochloride Tablets (Aricept)</td>
<td>3</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>5</td>
<td>Rituximab Injection (100mg)</td>
<td>3</td>
<td>Injection</td>
<td>Delivery</td>
</tr>
<tr>
<td>6</td>
<td>Rituximab Injection (500mg)</td>
<td>3</td>
<td>Injection</td>
<td>Delivery</td>
</tr>
<tr>
<td>7</td>
<td>Thymosin Alpha-1 sodium for Injection (Zadaxin)</td>
<td>3</td>
<td>Injection</td>
<td>Delivery</td>
</tr>
<tr>
<td>8</td>
<td>Cefpiramide sodium for Injection</td>
<td>3</td>
<td>Injection</td>
<td>Information</td>
</tr>
<tr>
<td>9</td>
<td>Cefepime Sodium for Injection (Maxipime)</td>
<td>3</td>
<td>Injection</td>
<td>Information</td>
</tr>
<tr>
<td>10</td>
<td>Cefotaxime Sodium for Injection</td>
<td>3</td>
<td>Injection</td>
<td>Information</td>
</tr>
<tr>
<td>11</td>
<td>Omeprazole Sodium for Injection</td>
<td>3</td>
<td>Injection</td>
<td>Information</td>
</tr>
<tr>
<td>12</td>
<td>Azithromycin Tablets (Zithromax)</td>
<td>3</td>
<td>Tablet</td>
<td>Information</td>
</tr>
<tr>
<td>13</td>
<td>Amiodipine Besylate Tablets (Norvasc)</td>
<td>3</td>
<td>Tablet</td>
<td>Self-checking</td>
</tr>
<tr>
<td>14</td>
<td>Calcitriol Soft Capsules</td>
<td>3</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>15</td>
<td>Azathioprine Tablets</td>
<td>3</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>16</td>
<td>Moxifloxacin Tablets</td>
<td>3</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>17</td>
<td>Cefaclor Capsules (Ceclor)</td>
<td>3</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>18</td>
<td>Cyclosporin Capsules</td>
<td>3</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>19</td>
<td>Prothrombin Complex Concentrate(Human),</td>
<td>4</td>
<td>Tablet</td>
<td>Self-checking</td>
</tr>
<tr>
<td>20</td>
<td>Itraconazole Injection</td>
<td>4</td>
<td>Injection</td>
<td>Delivery</td>
</tr>
<tr>
<td>21</td>
<td>Cefodizime Sodium for Injection</td>
<td>4</td>
<td>Injection</td>
<td>Information</td>
</tr>
<tr>
<td>22</td>
<td>Compound α-Ketoacid Tablets</td>
<td>4</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>23</td>
<td>Ofloxacin Tablets</td>
<td>4</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>24</td>
<td>Fluconazole Capsules</td>
<td>5</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>25</td>
<td>Tacrolimus Capsules</td>
<td>6</td>
<td>Tablet</td>
<td>Delivery</td>
</tr>
<tr>
<td>26</td>
<td>Lamivudine Tablet</td>
<td>6</td>
<td>Tablet</td>
<td>Information</td>
</tr>
</tbody>
</table>

Figure 11. Error causes.

computer system as soon as they dispense the drugs; as a result, drugs that the storage system has received are not added to the pharmacy’s inventory while the dispensing work of the pharmacy is going on. After dispensing drugs to the inpatient area, the storage was consumed, but the figure in the system cannot be listed as negative, and thus remains in the original data, resulting in discrepancies. For example, the original inventory of Drug A is 50 boxes and 100 boxes are added that very day, so the
current inventory is 150 boxes. But because this is not input into the account book immediately, the figure in the account book remains at 50. At this moment, if the inpatient area needs 60 boxes of Drug A that day, which exceeds the inventory, because the system cannot display the minus (it should be -10), the figure in the account book remains at the original 50. Therefore if the inventory is then checked, the real inventory of Drug A should be 90 boxes, which is inconsistent with the figure 50 in the account book; thus, discrepancies occur. The following is presented to solve this problem:

1) After dispensing the drugs, drug storage workers should input the information into the computer immediately, and the inpatient pharmacy supervisor will check the scheduled medication list. When no errors are found, the supervisor will ratify it in the computer system, and the drug administration work can then be completed.
2) The information section worker should deduct the drugs dispensed by the inpatient pharmacy in the information system when the storage workers have not input the information to the system. If the volume of drugs dispensed is larger than the volume of inventory in the information system, the volume of inventory should be displayed as a negative, which is favorable to the inpatient pharmacy’s checking work. This can be helpful for the analysis of discrepancies.

Establish standardized instructions for medicine management procedures in the inpatient pharmacy

Excluding these two external influential factors (information error and inventory not being input timely), the receiving sale and stock in the process are discussed thus.

Receiving: Drug administration

From the interview with the inpatient pharmacy supervisor, it is known that in the process, there are three factors that may result in inventory errors, which are as follows:

i. When drug storage workers are preparing the drugs, they may make errors; and this is not checked by inpatient pharmacy workers at the time they receive the drugs.
ii. When the drugs are unpacked and grounded, the packages are thrown away with some drugs left in them, which creates an incorrect number of drugs.
iii. Drug storage workers fill the wrong number and variety of the drugs in the account book, and the supervisor approves this without checking it out, which causes errors in the account book in the information system.

Points i and ii have occurred before, but iii has not yet happened. Therefore, the following are some improvement measures for i and ii:

Countermeasure 1: Current checking is limited to the supervisor’s checking in the drug storage and the checking of LCL (less than container load) drugs is ignored. Therefore, the charging pharmacist should check this for the second time before grounding, confirm the drugs received are consistent with that in the scheduled medication list, and then sign their name behind the item in the list.
Countermeasure 2: The work of grounding drugs is our colleagues’ daily activities in inpatient pharmacy, so that a registration form of the numbers of drugs that the staff assists in grounding should be made to enhance the staff’s enthusiasm. This form records colleagues’
between administrative departments should be encouraged, and the hospital should strengthen the commitment to quality and unwavering support, which can drive staff to be involved enthusiastically, combine the commitment of relevant members of the hospital, and become involved in the ongoing improvement to satisfy customers and enhance the overall quality of the hospital and staff.

**Sale: Dispensing drugs to the inpatient area**

The reason for dispensing drugs to the inpatient area leading to the discrepancy in checking by the inpatient pharmacy is “dispensing wrong drugs”, but the preparation-check rule is strictly followed during the process of dispensing drugs by the inpatient pharmacy. Currently, the number of errors in dispensing drugs has already been controlled effectively.

Another reason for discrepancies in checking by the inpatient pharmacy is factitious negligence and breakage, and most breakages are caused by a “packing barrier”. In order to reduce dispensing time, pharmacists fetch medicines rapidly which sometimes leads to the breakage of other medicines. For the problems caused by the “packing barrier”, it is better to unpack the medicines before they are put on the shelves, the medicines should be divided into moderate and small packages when unpacked, and pill boxes and tapes should be timely disposed of after being unpacked to prevent damages to medicines due to the “packing barrier”.

**Stock: the process of storing and checking medicines**

Analysis of the reasons for discrepancies in the real-time inventory shows that errors made by people during checking are one of the factors; experiences indicate that the cause of such a phenomenon is that the checking staff can not master the correct amount when the total number of big packages changes. The inpatient pharmacy supervisor has imitated the procedure of preparation when dispensing drugs, and inquired about following the examine-check rule to avoid errors in the process of checking.

To address these issues and improve the work, the QCC activities particularly formulate standardized “instruction of medicine management procedures in the inpatient pharmacy” to ensure the smooth implementation of a “real-time inventory” in the inpatient pharmacy, and integrate all aspects of the “real-time inventory” into daily management mode.

**DISCUSSION**

Reducing medication errors by QCC activities, means encouraging staff to fully participate in customer orientation. QCC activities emphasize the hospital’s commitment to quality and unwavering support, which can drive staff to be involved enthusiastically, combine the commitment of relevant members of the hospital, and raise their enthusiasm to achieve their goals through the improvement of ability. Members of QCC can take this opportunity to start benchmarking to improve their problem-solving abilities in the workplace, accept guidance and achieve the goal of self-realization. Interactions between administrative departments should be strengthened to increase the understanding of other

**Enhance the overall quality of the hospital**

In terms of a safe environment for medical treatment, medication error is the most important reason for medical errors and complications. QCC activities can reduce medication errors which directly decrease harm to patients, patients’ lives can be guaranteed and medical complications can be indirectly reduced. The hospital in this case masters the operational direction of the comprehensive performance of the overall quality management, plans its overall quality objectives, sets up mechanisms for diagnosis and evaluation issues, strengthens concepts in various meetings, interacts with members continuously, and improves the overall performance of the hospital. In addition to the tangible interests, the overall performance of the hospital contains intangible interests, including team spirit of a group, improvement of consciousness, analytical ability, participation, coordination of team members, and even the degree of cooperation between the management and the whole mechanism of the hospital. The management of the hospital leads members to view the quality management from the perspective of human beings, attach importance to qualitative healthcare sites, and improve the overall performance of the hospital. Activities to improve quality are integrated into the workplace of the hospital staff, which is in line with the integration and wholeness of the system, and the hospital’s QCC produce an upward trend in kinetic energy, so an organizational culture of enhancing the quality of the overall system is established. The hospital brings the results and countermeasures of QCC to the system of the hospital, persistently implements it according to the standardized operation procedure and sets up a cyclical operation system which can be constantly improved.

**Enhance the quality of hospital staff**

The hospital encourages its staff to participate in education and be trained on customer orientation, develop the QCC into a learning tool and form the QCC basis in which the staff continuously study and enhance quality. Management must firmly support staff, inspire their commitment to enhance the professional quality, and raise their enthusiasm to achieve their goals through the improvement of ability. Members of QCC can take this opportunity to start benchmarking to improve their problem-solving abilities in the workplace, accept guidance and achieve the goal of self-realization. Interactions between administrative departments should be strengthened to increase the understanding of other
departments’ business. Departments should jointly participate in creative thinking, combine the wisdom of the group, strengthen the ability of innovation and creation, give full play to the team’s synergy, and implement the mode of teamwork and team learning. Thereby, an upward energy is produced, and the team will become self-managed and efficient.

The centripetal force of colleagues in the hospital of this case has increased after this activity, and the activity has stimulated the team members’ potential and the motive to grow and study, increased thoughts of other fields instead of their own professions, and learnt to solve problems with tools in a scientific way and avoid solving problems according to subjective opinions or personal experiences. The theme of this activity is cross-department improvement, and due to the increased communication channels, drug dispensing is further known by other departments so as to reduce unnecessary misunderstandings. Moreover, positive interactions strengthen the emotions of both parties and make the discussion of relevant issues proceed more smoothly.

REFERENCES