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A refined management system focusing on medication dispensing errors: A 14-year retrospective study of a hospital outpatient pharmacy

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ABSTRACT

Objectives: This study aimed to evaluate the efficiency of a 14-year refined management system for the reduction of dispensing errors in a large-scale hospital outpatient pharmacy and to determine the effects of person-related and environment-related factors on the occurrence of dispensing errors.
Methods: A retrospective study was performed. Data on dispensing errors, inventory and account management from 2008 to 2021 were collected from the electronic system and evaluated using the direct observation method and the Plan-Do-Check-Act (PDCA) cycle.
Results: The consistency of the inventory and accounts increased substantially (from 86.93 % to 99.75 %) with the implementation of the refined management program. From 2008 to 2021, the total number of dispensing errors was reduced by approximately 96.1 %. The number of dispensing errors in quantity and name was reduced by approximately 98.2 % and 95.07 %, respectively. A remarkable reduction in the error rate was achieved (from 0.014 % to 0.00002 %), and the rate of dispensing errors was significantly reduced (0.019 % vs. 0.0003 %, $p < 0.001$). Across all medication dispensing errors, human-related errors decreased substantially (208 vs. 7, $p < 0.05$), as did non-human-related errors also (202 vs. 9, $p < 0.05$). There was a correlation between the occurrence of errors and pharmacists' sex (females generally made fewer errors than males), age (more errors were made by those aged 31–40 years), and working years (more errors were made by those with more than 11 years of work experience) from 2016 to 2021. The technicians improved during this procedure.
Conclusions: Refined management using the PDCA cycle was helpful in preventing dispensing errors and improving medication safety for patients.

1. Introduction

In recent years, patient safety has been a public concern in healthcare systems worldwide in recent years. The World Health Organization (WHO) defines patient safety as "the absence of preventable harm to a patient and reduction of risk of unnecessary harm associated with healthcare to an acceptable minimum". Medication errors are common in hospital pharmacies and can have a severely negative impact on patients. For example, a study reported a case of a 68-year-old woman who used methotrexate with a low-dose medication error (daily instead of weekly) leading to hepatic, hematological, and pulmonary toxicity (Silva et al., 2022). This case demonstrates that medication errors can be life-threatening. As the complexity of diseases increases, various types of medicines emerge on the market, leading to an increasing number of medication errors. According to the WHO, medication errors cost an estimated US $42 billion annually worldwide, which is 0.7 % of the total global health expenditure (Donaldson et al., 2017). The prevalence of medication errors is estimated to range from 2 % to 94 % depending on the practice setting (Koper et al., 2013; Assiri et al., 2018). In most cases, fatal errors result from dispensing errors such as incorrect medication or dosage. Therefore, reducing medication errors is essential to ensure patient safety. Medication errors may occur during the procuring, prescribing, dispensing, administration of medication and monitoring of patient responses, with dispensing errors being the most common. Dispensing errors usually occur due to confusion by medication names that sound or look alike, packaging, labeling, and similar strengths, dosage forms and frequencies of administration (Tseng et al., 2018; Mendes et al., 2018). Meanwhile, extensive studies have reported dispensing error rates, such as it was estimated to be up to 24 % in the United States outpatient pharmacies (Cheung et al., 2009; Beso et al.,

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2005), and in Brazil, it is estimated to be 10 % (Anacleto et al., 2005). Studies have also reported dispensing error rates of 0.0028 % to 13.28 % in China (Demirel, 2019). Detailed rules for the Implementation of Assessment Standards for Grade III in China once stipulated that "the annual error rate of outbound operations should be less than 0.01 %". Therefore, reducing dispensing errors is essential. Currently, dispensing errors are generally handled by implementing on-site solutions or improvement measures without any management involvement. In addition, although several interventions to reduce dispensing errors have been reported, such as the use of electronic prescriptions (Volpe et al., 2016; Kenawy and Kett 2019), robotic dispensing (Rodriguez-Gonzalez et al., 2019; Berdot et al., 2019; Sng, Ong, and Lai 2019), and medication error reporting systems (Holmström et al., 2019; Chen et al., 2019), comprehensive quality improvement programs to reduce medication errors in large-scale hospitals without automation equipment are rarely reported. All in all, practical and effective measures need to be implemented to reduce and prevent medication errors and ensure patient safety.

Plan-Do-Check-Act (PDCA) cycle is a continuous quality improvement cycle. A team was formed to plan, do, check and act these four links. Charts, flow charts, fishbone diagram, Plato, radar charts and other tools were used to complete the thorough solution of the core problems in three aspects:identifying the problems, analyzing the causes and solving the problems. In recent years, the PDCA cycle has become popular in hospital management to standardize the diagnosis and treatment behavior of doctors and nurses (Wei et al., 2022; Chen et al., 2020), improve patient care and promote quality management (Omar et al., 2020). Meanwhile, this method was also widely used to reduce drug dispensing errors.

Drug dispensing errors are common and continue to be made in every hospital. Therefore, reducing and preventing dispensing errors is an urgent problem in every hospital. This study analyzed the dispensing error rate in the pharmacy of West China Hospital from 2008 to 2021 after the large-scale hospital adopted refined management according to the PDCA cycle. West China Hospital of Sichuan University is the national center for the diagnosis and treatment of difficult and critical diseases in Western China. The outpatient and prescription numbers are approximately 15,000 and 12,000 per working day, respectively. Based on the number of prescriptions and patients, the hospital has a high-flow pharmacy among large hospitals in China and even abroad.

Examining the complexities of the diverse factors associated with dispensing errors can help to identify how these factors influence and ascertain possible strategies for improved patient safety. Therefore, this study aims to investigate the effectiveness of a 14-year refined management system which without any modern equipment in reducing dispensing error rate in pharmacy, and to determine the effects such as person-related and environment-related factors for the occurrence of dispensing errors. Meanwhile, the implementation of the project achieved remarkable results, which the consistency of the inventory and accounts was 99.75 %, and the rate of dispensing errors was 0.0003 %, both of which were lower than previously reported studies. We examined the effectiveness of this stewardship intervention also in outpatient care and provide a reference for international counterparts.

2. Methods

This study was a retrospective review of 14-year of medication safety management by collecting data on medication inventory, accounts and dispensing errors from January 2008 to December 2021 at West China Hospital of Sichuan University, aiming to reduce the occurrence of dispensing errors through intervention measures. Since refined management was implemented in 2009, and 2008 used as a control to compare the change trend before and after implementation. This study was conducted in the West China Hospital outpatient pharmacy, which employs approximately 85 pharmacists, the pharmacists who were mainly responsible for prescription review, drug dispensing, drug distribution and medication guidance. Meanwhile, during the study period, a little of pharmacists had staff changes, such as resignation. The number of people served by this project was approximately 41 million, which was the total number of patients who were prescribed drugs during the study period.

The PDCA (Plan-Do-Check-Act) cycle (Fig. 1) divides the process of management into four parts to identify and solve problems. To reduce dispensing errors, PCDA was also introduced at the hospital.

2.1. Data collection and procedure

The study collected data on the number of prescription and dispensing error over the 14-year period and were used for data collection and analysis. All dispensing errors submitted from 2008 to 2021 were included. For many years, we checked and reported daily dispensing errors by taking a daily inventory of medicines in this study, submit and record all errors in accordance with regulations, and reward and punishment. The reporting process of dispensing errors was designed in accordance with the American Society of Health-System Pharmacists (ASHP) Guidelines on Preventing Medication Errors in Hospitals. Data collector who agreed to volunteer in this study received adequate training on the study objectives, materials, and the data collection form before study initiation. The data collection included the number of prescription, specific information on the dispensing errors (e.g., types and causes).

2.2. Inclusion and exclusion criteria

The study's inclusion criteria were as follows:the prescriptions should be medication-related (not lab tests orders). All prescriptions were outpatient prescriptions (handwritten or computerized), prescriptions without medication errors were excluded. Besides, inpatient, or self-prescription were excluded. Prescriptions were excluded in case of a lack of confident medical data (previous medical and medication history).

2.3. Intervention measures

I) "Plan" stage

In terms of the risk points in the fishbone diagram (Fig. 2), the major factor affecting medication safety was dispensing errors resulting from human error and management issues. To improve this situation, a refined management system was established to improve the management of the dispensing window, error management, medicine management and personnel management.

II) "Do" stage

(1) *Window management:*A working shift dynamic management method was used to reduce the risk of medication delivery and avoid mistakes. Twenty working shifts were arranged according to the patient flow.
(2) *Error management:*Internal error (near-misses) management and external error management were established to reduce dispensing errors. Internal error (near-misses) management included making internal error record sheets and encouraging staff to complete the sheets and giving rewards, and collecting statistics and analyzing the error data and handling of problems without delay. External error management included that we check daily dispensing errors by taking a daily inventory of medicines. Further, we strengthened management by means of self-education, self-error analysis and assessment, provide case analysis and training for all employees, and give detailed performance appraisals.
(3) *Medicine management:* Bold labels were applied for easily confused medications. Independently develop an electronic label

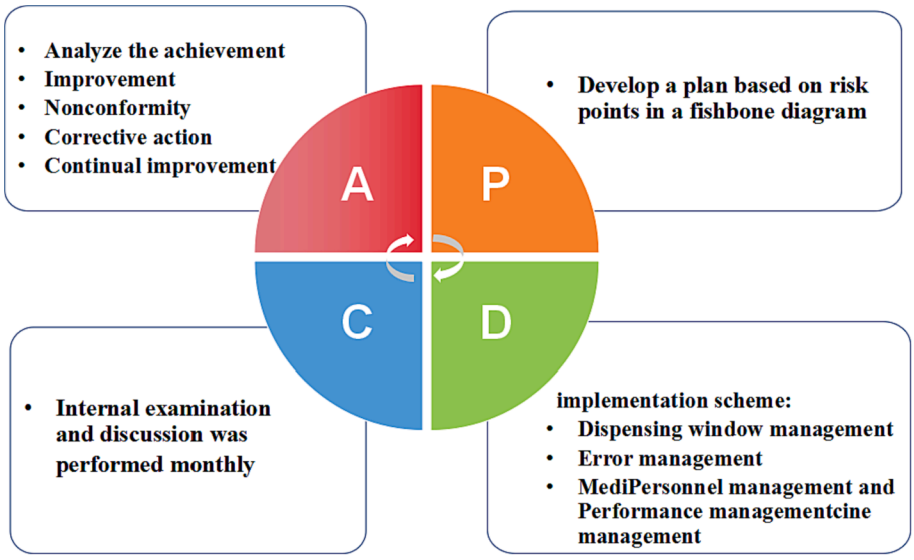

Fig. 1. Implementation effect diagram of the PDCA cycle.

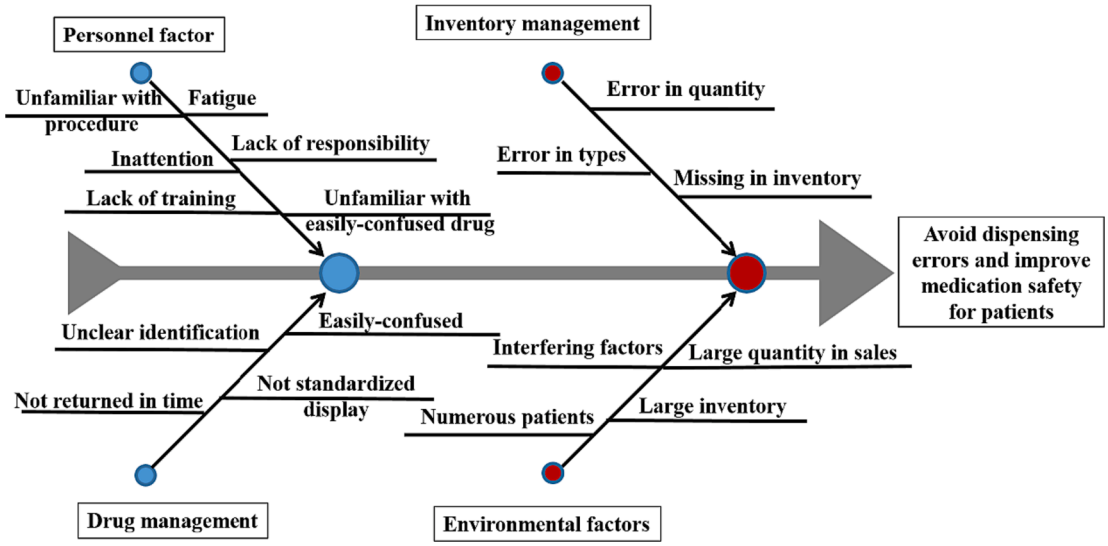

Fig. 2. Fishbone diagram of risk points that affect medication safety.

printing system. Create a refined inventory record according to the kinds of medication.

(4) *Personnel management and performance management:* Pre-job training was provided for each technician. Professional knowledge training and assessment were performed weekly. In addition, personnel performance was associated with performance assessments.

III) "Check"stage

Internal examination and discussion were performed monthly to discuss the problems and dispensing errors during the implementation period.

IV) "Act"stage

The achievement of each measure was analyzed. Successful measures were established as standards, while unsuccessful measures were reformulated for a new round of improvement projects the following year.

2.4. Data processing

After one year of management using the PDCA cycle, the data on medication inventory, accounts and dispensing errors were analyzed using chi-square and t tests. A p value of less than 0.05 was considered significant.

In this study, the calculation methods for the consistency rate of the inventory and accounts, the error rate of inventory amounts, and the rate of dispensing errors were as follows:

$$\text{The consistency rate of inventory and accounts} = \frac{\text{The numbe of compliant medicines}}{\text{The number of all medicines}} \times 100\%$$

$$\text{The error rate of inventory amounts} = \frac{\text{The loss amount}}{\text{The number of total sales}} \times 100\%$$

$$\text{The rate of dispensing errors} = \frac{\text{The number of dispensing errors}}{\text{The total amount of prescriptions dispensed}} \times 100\%$$

2.5. Statistical analysis

The statistical analysis was performed using SPSS version 20 (IBM Corp., Atlanta, GA, USA). All data entered into the computer were double-checked for accuracy by random assessment. Descriptive statistics were applied for data variables. The paired *t* test was used to measure the difference in dispensing errors across error categories and sources of error occurrence. A p value < 0.05 was considered to be statistically significant.

2.6. Ethics statement

This retrospective study was approved by the Biomedical Ethics Review Committee, West China Hospital, Sichuan University (Ethics Approval Number 2023-1773).

3. Results

3.1. The refined medicine management system improved the consistency of inventory and account management

In this study, we monitored the consistency rate of inventory and accounts before and after the implementation of a refined medicine management system. As shown in Fig. 3(A), the consistency rate of the inventory and accounts was 86.93 % in 2008. In 2014, the consistency rate had increased to 99.13 %, showing remarkable results. From 2014

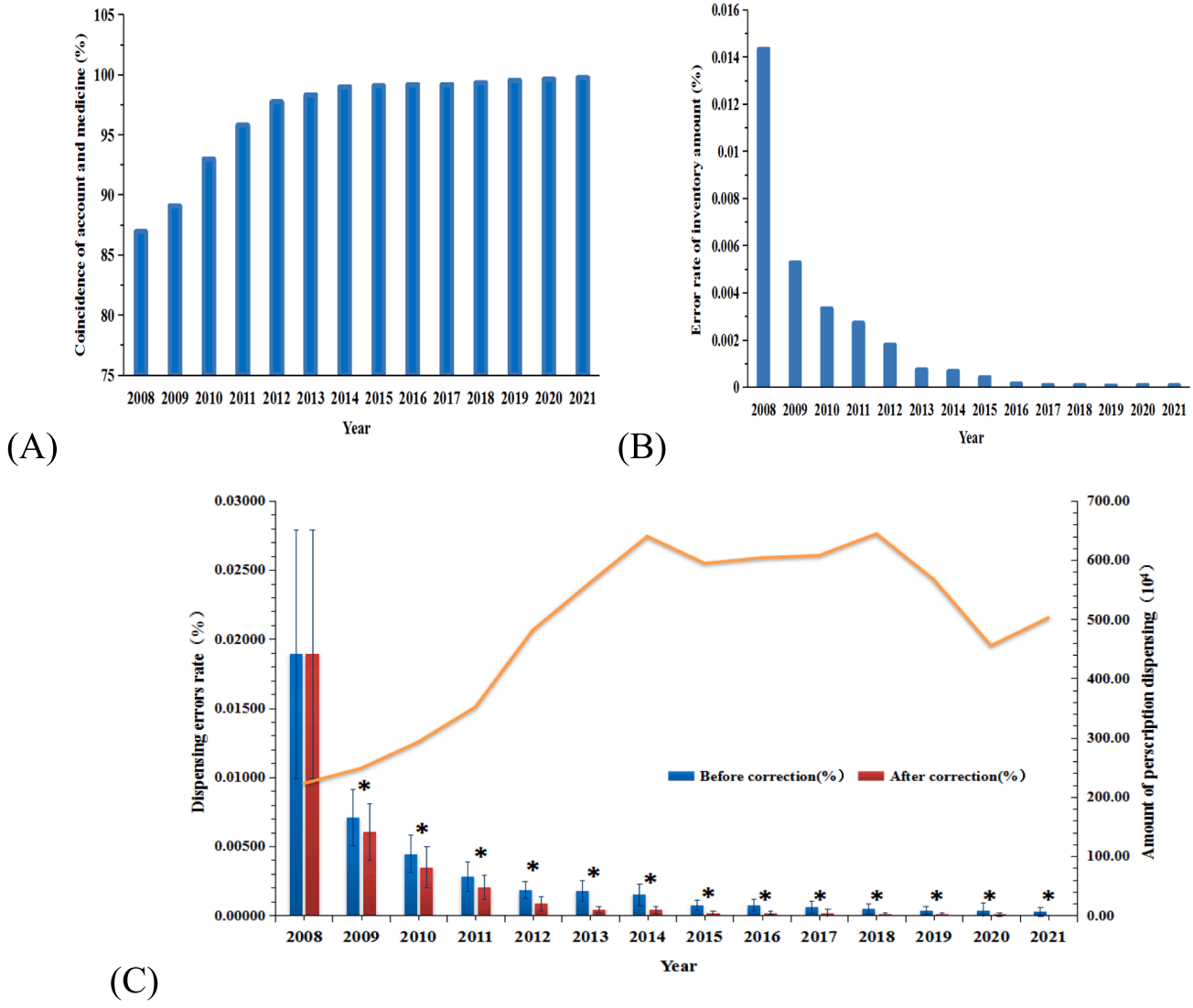

Fig. 3. Consistency rate of inventory and accounts (A), error rate of inventory amount (B) and error rate of dispensation and number of prescriptions (C) from 2008 to 2021.

to 2021, the rates were all above 99 % and reached 99.75 % in 2021. This shows that the consistency of the inventory and accounts was very high, which was very important for ensuring the safety of state-owned assets. Moreover, the inventory error rate was also monitored (Fig. 3 (B)). In 2008, the error rate was 0.014 %, which was quite high due to the hospital's high volume of medications. After refined management for one year, the error rate was reduced to 0.005 % and was further reduced to 0.0002 % by 2021. The results indicated that the medication safety related to dispensing errors greatly improved.

3.2. The refined medicine management systems significantly reduce dispensing errors

In 2008, 410 dispensing errors were detected, and this number decreased by 96.1 % in 2021 (Table 1). Most of the medication errors during dispensing that year arose from incorrect medications, including incorrect quantities (224) and names (142). These two types of errors accounted for more than 85 % of the medication errors. In 2021, dispensing errors in quantity and name were reduced by approximately 98.2 % and 95.07 %, respectively. The refined medicine management system significantly reduced the error rate. As shown in Fig. 3(C), the error rate was 0.019 % in 2008. However, by 2021, the number of prescriptions had increased by 2.26-fold, while the error rate had declined significantly to 0.00033 % ($p < 0.001$). This indicated that the measures significantly improved the awareness of medication safety among personnel.

3.3. The refined medicine management system reduced dispensing errors caused by human and nonhuman sources

Dispensing errors can arise from either human or nonhuman sources, such as medication or the environment. The impacts of dispensing errors due to human and nonhuman medication sources were investigated. Out of 410 total dispensing errors found in 2008, 208 errors (50.73 % of the total errors) were associated with health care professionals (i.e., "human sources"), mostly from memory-based mistakes. Medication-related (i.e., "nonhuman") errors (44 errors) accounted for 10.73 % of the total errors. Moreover, the number of dispensing errors associated with the environment was 158, accounting for 38.54 % of the total errors. In 2021, the number of these 3 types of errors dropped to 7 (down 96.63 %, $p < 0.05$), 1 (down 97.73 %, $p < 0.05$) and 8 (down 94.94 %, $p < 0.05$) respectively. In total, the number of dispensing errors found that were related to a nonhuman source decreased substantially from 202 (49.27 % of the total) in 2008 to 9 (56.25 % of the total) in 2021 with $p < 0.05$ (Table 2).

Human-associated errors account for a large proportion of all medication dispensing errors. Therefore, we also studied the correlation between the occurrence of errors and the sex, age, and working years of pharmacists from 2016 to 2021. The number of dispensing errors (number of errors/number of people) among female pharmacists decreased from 0.88 to 0.25, which was generally lower than that among male pharmacists (Fig. 4). The number of dispensing errors was higher in the age group of 31–40 age group (Fig. 5). As Fig. 6 shows, pharmacists with more than 11 years of work experience had more dispensing errors (0.46 in 2021), followed by those with 6–10 years of work experience (0.31 in 2021).

3.4. Improving the target achievement and improvement rates

To evaluate the implementation effect, the target achievement rate and target improvement rate were calculated as follows:

Target achievement rate = ($Rate_{after\ implementation}$ - $Rate_{before\ implementation}$)/($Rate_{target}$ - $Rate_{before\ implementation}$) × 100 %.

Target improvement rate = ($Rate_{after\ implementation}$-$Rate_{before\ implementation}$)/$Rate_{before\ implementation}$ × 100 %.

Table 1
Causes of ~~the~~ dispensing errors at the pharmacies from 2008 to 2021.

Error type						Wrong medicine				Quantity	Usage and dosage	Formulation	Dosage form	Wrong patient	Prescription checking
Year	The total number of prescriptions	The rate of dispensing errors (Before)		The rate of dispensing errors (After)		Medications name similar	Medications looks similar	Manufacturer	Other						
		Number of cases	Percentage of total	Number of cases	Percentage of total	Number of cases	Number of cases	Number of cases	Number of cases	Number of cases	Number of cases	Number of cases	Number of cases	Number of cases	Number of cases
2008	2,226,599	410	0.0184 %	410	0.0184 %	37	7	68	30	224	0	27	17	0	0
2009	2,483,208	174	0.0070 %*	149	0.0060 %*	7	32	19	2	109	0	4	1	0	0
2010	2,927,333	132	0.0045 %*	104	0.0036 %*	13	5	25	8	68	0	9	4	0	0
2011	3,518,877	115	0.0033 %*	88	0.0025 %*	7	2	35	17	36	2	14	1	1	0
2012	4,814,651	89	0.0018 %*	40	0.0008 %*	10	5	22	21	20	0	7	3	1	0
2013	5,618,174	100	0.0018 %*	20	0.0004 %*	15	7	9	9	40	4	5	1	3	7
2014	6,399,107	100	0.0016 %*	26	0.0004 %*	10	1	16	13	44	0	14	0	0	2
2015	5,944,248	45	0.0008 %*	11	0.0002 %*	1	0	7	9	20	0	3	2	3	0
2016	6,037,942	48	0.0008 %*	12	0.0002 %*	2	0	11	7	20	0	7	0	1	0
2017	6,076,387	40	0.0007 %*	10	0.0002 %*	7	1	7	6	17	1	1	0	0	0
2018	6,443,027	29	0.0004 %*	4	0.0001 %*	1	1	4	4	10	2	3	1	3	0
2019	5,669,545	22	0.0004 %*	1	0.00002 %*	4	3	4	1	8	2	0	0	0	0
2020	4,552,784	20	0.0004 %*	1	0.00002 %*	1	0	6	2	7	1	0	3	0	0
2021	5,024,086	16	0.0003 %*	0	0*	1	0	4	3	4	0	0	1	3	0

* = comparison with 2008 statistically significant ($P < 0.05$).

Table 2
Source of dispensing errors from 2008 to 2021.

Source	Reason	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Human	**Habitual processing**	81	20	18	15	11	10	14	6	4	3	2	4	3	2
	Poor concentration	30	18	16	14	9	7	10	7	6	4	3	2	2	2
	Multitasking	76	24	20	18	11	9	12	6	7	4	2	0	1	0
	Miscalculation of medication	0	0	0	2	0	4	0	0	0	1	2	2	1	0
	Distracted due to talking	21	11	8	9	6	4	3	2	3	2	1	0	0	0
	Knowledge deficit	0	0	0	0	0	7	2	0	0	0	0	0	0	0
	Inadequate screening of patient	0	0	0	1	1	3	0	3	1	0	3	0	0	3
Total human errors		**208 (50.73 %)**	**73 (41.96 %)** *	**62 (46.97 %)** *	**59 (51.30 %)** *	**38 (42.70 %)** *	**44 (44.00 %)** *	**41 (41.00 %)** *	**24 (53.33 %)** *	**21 (43.75 %)** *	**14 (35.00 %)** *	**13 (44.83 %)** *	**8 (36.36 %)** *	**7 (35.00 %)** *	**7 (43.75 %)** *
Medication	**Medication names similar**	37	7	13	7	10	15	10	1	2	7	1	4	1	1
	Medications look similar	7	32	5	2	5	7	1	0	0	1	1	3	0	0
Total		**44 (10.73 %)**	**39 (22.41 %)**	**18 (13.64 %)** *	**9 (7.83 %)***	**15 (16.85 %)** *	**22 (22.00 %)** *	**11 (11.00 %)** *	**1 (2.22 %)***	**2 (4.17 %)***	**8 (20.00 %)** *	**2 (6.90 %)***	**7 (31.82 %)** *	**1 (5.00 %)** *	**1 (6.25 %)** *
Environmental	**Proximity of medications**	20	11	7	9	3	2	3	2	0	0	0	0	0	0
	Peak hours of a shift	60	19	18	13	14	11	15	8	11	5	6	4	4	3
	Near the end of a shift	33	11	12	11	3	7	11	4	5	2	3	1	1	0
	Pressured by the patient	45	21	15	14	16	14	19	6	9	11	5	2	7	5
Total		**158 (38.54 %)**	**62 (35.63 %)** *	**52 (39.39 %)** *	**47 (40.87 %)** *	**36 (40.45 %)** *	**34 (34.00 %)** *	**48 (48.00 %)** *	**20 (44.44 %)** *	**25 (52.08 %)** *	**18 (45.00 %)** *	**14 (48.28 %)** *	**7 (31.82 %)** *	**12 (60.00 %)***	**8 (50.00 %)***
Total nonhuman errors		**202 (49.27 %)**	**101 (58.04 %)** *	**70 (53.03 %)** *	**56 (48.70 %)** *	**51 (57.30 %)** *	**56 (56.00 %)** *	**59 (59.00 %)** *	**21 (46.67 %)** *	**27 (56.25 %)** *	**26 (65.00 %)** *	**16 (55.17 %)** *	**14 (63.64 %)** *	**13 (65.00 %)** *	**9 (56.25 %)** *

* = comparison with 2008 statistically significant ($P < 0.05$).

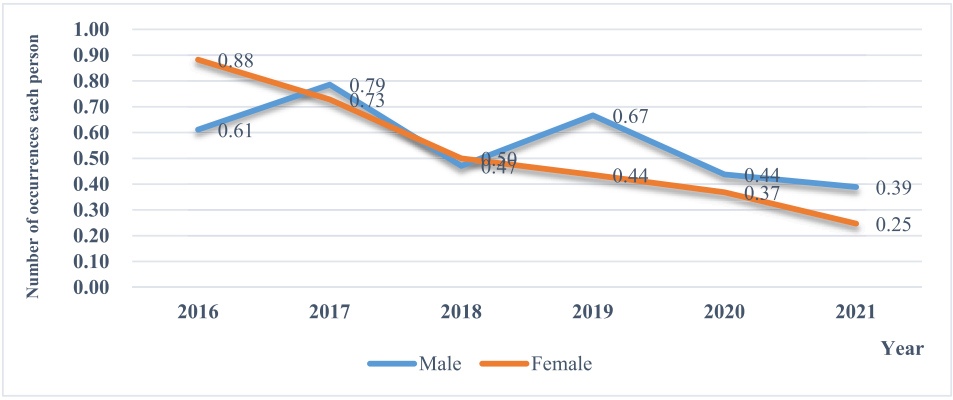

Fig. 4. Comparison of the number of dispensing errors among males and females from 2016 to 2021.

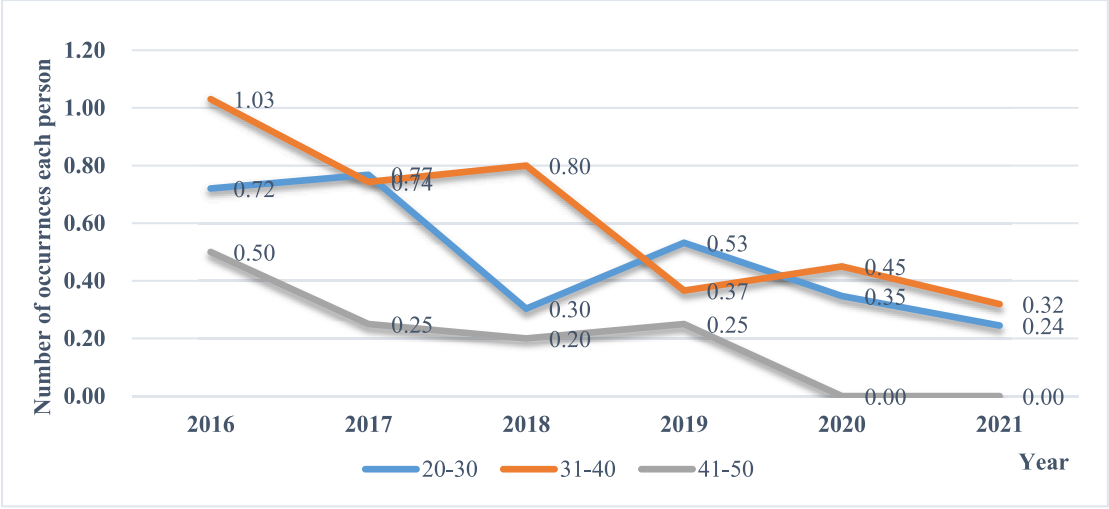

Fig. 5. Comparison of the number of dispensing errors by age group from 2016 to 2021.

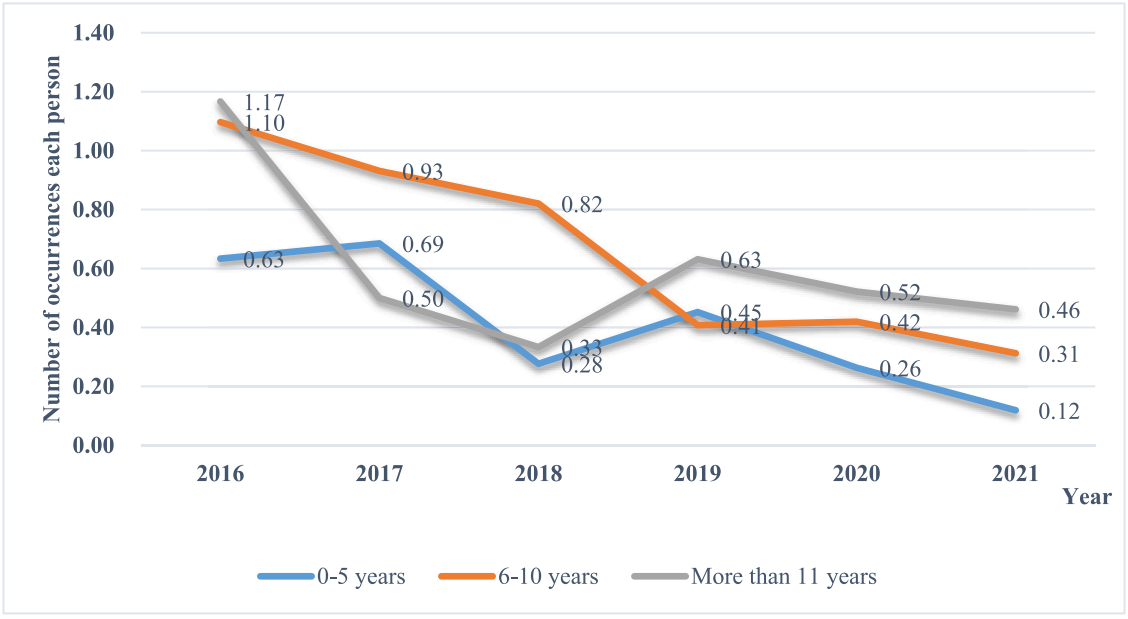

Fig. 6. Comparison of the number of dispensing errors related to years of work experience from 2016 to 2021.

Table 3
Target achievement rate and target improvement rate after project implementation.

	Before implementation	Target value	After implementation	Target achievement rate	Target improvement rate
Rate of dispensing errors (%)	0.018923	0	0.00033	98.25	98.25
Consistency rate of inventory and accounts (%)	86.93	100	99.75	98.09	14.75
Error rate of inventory amount (%)	0.01433	0	0.00002	99.86	99.86

The evaluation results are shown in Table 3. From the results, the target achievement rates for the rate of dispensing errors, consistency rate of inventory and accounts, and error rate of inventory were 98.25 %, 98.09 % and 99.86 %, respectively. This indicated that the implementation effect met expectations. In addition, the target improvement rates for the rate of dispensing error and error rate of inventory amount were 98.25 % and 99.86 %, respectively, revealing that great progress had been made in this project.

3.5. The refined medicine management system ~~has~~ greatly improved ~~the~~ staff capacity

To understand the improvement in staff capacity during this project, we surveyed technicians before and after the project. According to the questionnaire results, the activity, responsibility, cohesion, problem-solving, communication and team cooperation abilities of all technicians were evaluated and scored. Each technician had a maximum score of 5 points and a minimum score of 1 point for each item. Then, a radar map was drawn. Fig. 7 shows that the project ~~has~~ greatly improved staff capacity for all technicians.

4. Discussion

Medication safety is incredibly important for patient safety. Studies from the UK and elsewhere have highlighted the prevalence of medication errors in primary care. The outpatient pharmacy in the hospital is the direct contact department for patients after medical treatment. In West China Hospital, we encounter a large number of patients every day, and a small number of management failures will lead to serious medical malpractice. Thus, an advanced and comprehensive management system is essential to ensure medication safety. Medication errors occur at all steps of the medication process, especially at the dispensing stages. Identifying the problems at each step will help managers make more effective rectification plans. Medication safety is the core content of pharmaceutical management. The most concerning and difficult problem is to ensure that the medication is dispensed accurately and that the inventory is consistent with the accounts. Our 14-year period study shows that using the refined management system was able to markedly reduce the number of dispensing errors, and improve the consistency of inventory and account management.

To address these dispensing errors, the hospital pharmacy employed a range of methods, including the PDCA quality control cycle (Wang et al., 2015), root cause analysis (Bagian et al., 2002) and the 80/20 law (Cohen and Mandrack 2002). PDCA cycle management is a common quality management model used in various management tasks. The aim is to improve hospital management and guarantee patient safety. In this study, we thoroughly analyzed the risk points affecting medication safety and summarize the major issues resulting in dispensing errors. After PDCA management, the data on medication inventory, accounts and dispensing errors were collected, analyzed and formulated for a new round of improvement procedures to address unachieved aims. The quality control framework approach outlined in the PDCA cycle practice was adopted to ultimately reduce medication errors.

Hospital pharmacy services have been shown to facilitate appropriate prescriptions and reduce medication errors (Bond and Raehl 2008; Bond, Raehl, and Franke 2002). In the present study, we comprehensively analyzed the risk points affecting medication error and summarized the major issues. Because West China Hospital serves a

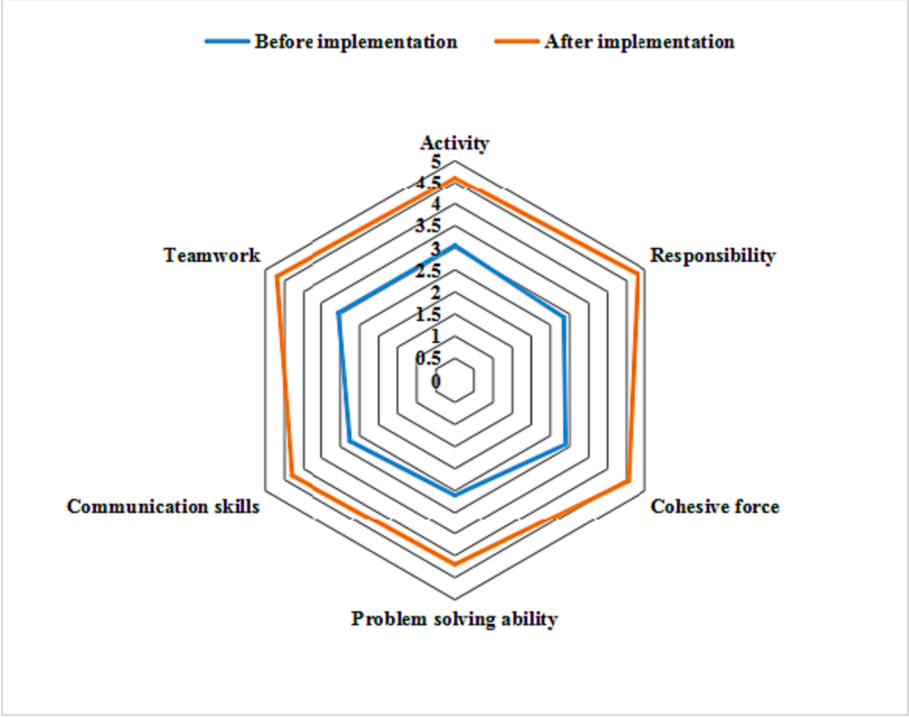

Fig. 7. Radar map of staff capacity changes before and after ~~the~~ refined management.

large population, the workload of dispensing medications is enormous. Technicians inevitably were tired and distracted and sometimes ignored standard procedures. In addition, new employees might be unfamiliar with the procedures and confuse medications. To solve this problem, we first divided the dispensing windows into six categories and implemented working shift dynamic management to ensure that the number of technicians on duty matched the patient flow at the dispensing windows. This measure also ensured time off for technicians, so that they could concentrate on their work and reduce the occurrence of dispensing errors caused by fatigue. In addition, pre-job training and weekly professional knowledge training were provided for established and new technicians to improve their skills, in order to prevent the occurrence of dispensing errors.

An internal error record sheet was another innovation in this management program and was the last line of defense for dispensing errors. The medication was recorded after the prescription was filled and before the medication was delivered to the patient. This measure mean that the medication was double-checked by different technicians to minimize the occurrence of dispensing errors and ensure patient safety.

With many different kinds of medicines being rapidly brought to market, some medications look and sound similar to other medications. This is easily confusing for technicians. Therefore, bold labels were applied to these look-alike/sound-alike medications. These partitions and eye-catching labels can help technicians choose the correct medicines.

The consistency of inventory and accounts was an important index to evaluate whether the medicine was dispensed correctly. Thus, a dynamic physical inventory was performed daily to examine the number of medicines, and an astatic physical inventory combined with financial supervision was performed monthly to examine the consistency of the accounts.

At the monthly meeting, each staff member participated in a discussion of the problems, sharing what they had learned from work and the dispensing error management system. After 14 years of the refined medicine management system from 2008 to 2021, the consistency rates of inventory and accounts significantly increased from 86.93 % to 99.75 %. The error rate of the inventory declined from 0.014 % to 0.0002 %, as did the rate of dispensing errors from 0.019 % to 0.00033 % ($p < 0.001$). Studies have shown that the dispensing error rate was 1.6 % to 2.92 % in hospitals or community pharmacies during the dispensing stage (Soubra and Karout 2021). The dispensing error rate of our study was substantially lower than these values. It was well known that by reducing the dispensing error rate, the impact of medication errors on patients can be reduced and the safety of medication for patients can be ensured. Meanwhile, there was few published study about the effect of the refined management model without any modern equipment on dispensing errors.

In 2002, the ASHP developed a series of guidelines for pharmacy practices. The ASHP guideline “Preventing Medication Errors in Hospitals” states that the majority of ADRs are associated with the practices of pharmacists, physicians, and nurses. Therefore, addressing human errors, creating better education approaches and increasing the strong involvement of healthcare specialists and patients would be helpful in reducing medication errors(Frush et al., 2006; Roque et al., 2014). Human factors contributed to more than 50 % of all medication dispensing errors recorded in 2008. Since 2009, all new staff and trainees have received intensive training for proper medication use, such as sharing and discussing the causes of dispensing errors, and pre-job training. There were marked improvements in the performance of personnel in our study. After the intervention of the above refined system initiatives, the technicians greatly improved in problem-solving, communication and team cooperation abilities. As a result, the number of medication dispensing errors due to human error was massively reduced (down 96.63 %). These results indicated that the refined medicine management system is a powerful tool for medication management in hospital outpatient pharmacies. Moreover, we also studied the correlation between the occurrence of errors and the sex (females generally made fewer errors than males), age (more errors were made by those aged 31–40 years), and working years (more errors were made by those with more than 11 years of work experience) of pharmacists from 2016 to 2021.

The refined management system of this study was executed without any modern equipment (e.g., automatic dispensers). However, the implementation of the project achieved remarkable results, and the dispensing error rate was lower than that of outpatient pharmacies with modern equipment, ranking in the forefront of the industry. Our study provides insights and ideas for decision-makers in healthcare institutions to improve medication safety, such as the importance of ongoing education and training in healthcare settings, take turns checking medicines daily, and applied working shift dynamic management. In addition, the operation mode of the project has also been promoted and used for reference in other hospitals and sister units of our hospital, indicating that the model could be applied to other hospital. At the same time, its management concept and methods are also suitable for outpatient pharmacies with modern equipment. However, if the implementation of the fine management degree was not in place, it might affect the implementation in different settings.

5. Strengths and limitations

The advantage of this study is that it is the first to report the successful management experience of the PDCA cycle in a large hospital outpatient pharmacy to improve medication safety. Our study also has some limitations, this study has focused the stage of dispensing. Since medication error also happens during other stages like medication administration and monitoring the effect of the medicine to the patient. Another limitation was that further efforts should be made with observations on the benefits of training and raising awareness in increasing medication safety.

6. Conclusion

Medication errors are the most common preventable cause of undesired adverse events in medical practice and present a major public health burden. Thus, improving medication safety for patients is very important. The refined management system with PDCA had a positive impact on reducing the medication errors. Quality control is an important tool for technicians promoting medication safety awareness and skills. Investigation of the reasons for dispensing errors is helpful in implementing safe dispensing management. Further studies to investigate the impact of the refined management system using PDCA method in other hospital, and to be compared with the traditional management mode on dispensing errors frequency for the same prescribers are needed.

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Declaration of Competing Interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

No new data were generated or analyzed in support of this review.

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