

1 **Title Page**

2 **Refinement of management effectively reduces dispensing errors: 12-year**  
3 **experience from an outpatient pharmacy**

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6 **Running title:** Refinement of management.

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13 **Data availability statement**

14 The data that support the findings of this study are available from the corresponding  
15 author upon reasonable request.

16 **Conflict of interest statement for all authors**

17 The authors declared no potential conflicts of interest with respect to the research,  
18 authorship, and/or publication of this article.

19

20 **ABSTRACT**

21 *Objective:* Medication errors in hospital outpatient pharmacy have a serious negative  
22 impact on people's health and economy. To assess the efficiency of 12-year refined  
23 management using PDCA cycle on reducing the dispensing errors in a large-scale  
24 hospital outpatient pharmacy.

25 *Methods:* A retrospective study of dispensing errors was performed. Data for  
26 dispensing errors, stocks and accounts management from 2008 to 2019 was collected  
27 from the electronic system and evaluated using direct observation method.

28 *Results:* The consistent rate of the stocks and accounts was significantly increased  
29 (86.93% vs 99.54%,  $p < 0.05$ ). A remarkable reduction of error rate was achieved  
30 (0.014% vs 0.0006%,  $p < 0.05$ ) and the rate of dispensing errors was significantly  
31 reduced (0.019% vs 0.000034%,  $p < 0.05$ ). Besides, the technicians improved  
32 themselves during this procedure.

33 *Conclusion:* the refined management using PDCA cycle was helpful to prevent the  
34 dispensing errors and improve medication safety for patients.

35

36 **Keywords:** refinement of management, dispensing errors, PDCA cycle, performance  
37 management, medication safety

38 **Introduction**

39 Improving the safety of healthcare services become an international priority and  
40 widely concerned issue in recent years. The outbreak of COVID-19 made people  
41 more aware of their health, and making medical safety a hot topic. Medication errors  
42 are common in hospital pharmacy and have a serious negative impact on people's  
43 health and economy.<sup>1</sup> As the complexity of the disease increases, various types of  
44 medicines emerge on the market, which leading to growing medication errors. As  
45 stated by the Institute of Medicine (IOM) report, 98,000 people died annually due to  
46 medication related errors in the United States.<sup>2</sup> Therefore, reducing the medication  
47 errors was essential to ensure the safety of peoples' medication. Medication errors  
48 may occur during the procuring, prescribing, dispensing, administering the drugs and  
49 monitoring the patient's responses.<sup>3</sup> Among these sections, dispensing error is the  
50 most common occurrence. Dispensing errors usually happens due to the confusion of  
51 the look-alike or sound-alike drug names, packaging, labeling, and similar strengths,  
52 dosage forms and frequency of administration.<sup>4-7</sup> The European Medicines Agency  
53 had estimated in European hospitals that the dispensing error rate was 1.6% to 2.1%  
54 during the dispensing stage.<sup>8</sup> The numerical values were up to 12.5% in hospital  
55 outpatient pharmacies in the USA,<sup>9-12</sup> and above 10% in Brazil.<sup>13, 14</sup> Studies also  
56 reported that dispensing error rates were 0.0028% to 13.28% in China.<sup>15, 16</sup> However,  
57 detailed rules for the Implementation of Assessment Standards for Grade III in China  
58 stipulated that "the annual error rate of outbound operations should be less than  
59 0.01%". Therefore, reducing the dispensing errors is essential for hospitals to take

60 effective measures. Currently, the handling of the dispensing errors generally adopted  
61 on-site solution or proposing improvement measures without any management  
62 measures. Besides, although several interventions for reducing dispensing errors have  
63 been reported as using electronic prescription,<sup>17-19</sup> robotic dispensing,<sup>20-22</sup> medication  
64 error reporting system etc.,<sup>23, 24</sup> comprehensive quality improvement programs on  
65 medication errors in large-scale hospitals without automation equipment are rarely  
66 reported. For this, practical and effective measures need to be taken to reduce and  
67 prevent medication errors and ensure drug safety for patients.

68 The PDCA (P: plan, D: do, C: check, A: act) cycle management practice is a  
69 continuous quality improvement cycle. It divides the process of management into four  
70 parts containing the process of finding and solving problems. In recent years, PDCA  
71 method was popular in hospital management to standardize the diagnosis and  
72 treatment behavior of doctors and nurses,<sup>25, 26</sup> improve patient care and promote the  
73 quality management.<sup>27</sup> However, this method had not been applied for the reduction of  
74 dispensing errors.

75 In this manuscript, we analyzed the dispensing error rate changes from 2008 to  
76 2019 after adopting a refined management according to PDCA cycle in the pharmacy  
77 of a large-scale hospital, West China Hospital (WCH). WCH is the national center for  
78 the diagnosis and treatment of difficult and critical diseases in western China. The  
79 outpatients and prescription number are about 15000 and 12000 per working day. A  
80 refined medicine management system focusing on security for medicine use was  
81 established from four aspects: dispensing window management, error management,

82 medicine management, and personnel management. We discussed the effectiveness of  
83 such stewardship intervention in inpatient care and provided some reference for  
84 international counterparts.

## 85 **Methods**

86 A retrospective study of 12-year drug safety management in WCH outpatient  
87 pharmacy was performed. Data of drug stocks, accounts and dispensing errors was  
88 collected from January 2008 to December 2019 with data of 2008 used as control.

### 89 **Risk points of medication safety**

90 A fishbone diagram (Figure 1) was used to find out the risk points that affect the  
91 medication safety, which covered four aspects: personnel factors, drug management,  
92 inventory management and environmental factors. Based on the analysis results of the  
93 fishbone diagram, we developed a PDCA cycle (Plan-Do-Check-Act) (Figure 2) for  
94 quality improvement.

#### 95 **“Plan” stage**

96 In terms of the risk points in fishbone diagram, the major factor affecting  
97 medication safety was the dispensing errors resulting from human factor and  
98 management disorder. To improve this situation, a refined management system was  
99 established from the aspects of dispensing window management, error management,  
100 medicine management and personnel management.

#### 101 **“Do” stage**

##### 102 ***Dispensing window management***

103 A working shifts dynamic management method was used to reduce the risk of  
104 drug delivery and avoid mistakes.

105 (1) Adjust the number of dispensing windows according to the prescriptions  
106 number in different time periods, making the window running match the opening  
107 hours and patients flow.

108 (2) Subdividing the dispensing window into six categories including general  
109 patients window, cancer patients window, cadre health care window, special needs  
110 patients window, hospital staff window, and counseling window.

111 (3) Arranging twenty working shifts according to the patient flow.

112 (4) Making a window inspection and post spot check to control the quality.

### 113 ***Error management***

114 Internal error management and external error management were established to  
115 reduce the dispensing errors.

#### 116 (1) Internal error management

117 Internal error management was adopted for dispensing personnel to build safety  
118 awareness, and avoid mistakes.

119 ● Making internal error record sheets

120 ● Encouraging staffs to fill in the sheets and giving reward

121 ● Making statistics and analysis of the error data and handling the problems without  
122 delay

123 ● Discussing and evaluating the internal errors on monthly meeting, and  
124 incorporate the internal errors into performance appraisal

#### 125 (2) External error management

126 Strengthen management by means of self-education, self-error analysis and  
127 assessment, case analysis and training for all employees, and making detailed

128 performance appraisal.

129 ***Medicine management***

130 ● A principle of three-color and five-area classification was performed to  
131 standardize the drug display.

132 ● Applying bold labels for easily confused drug.

133 ● Independent development of electronic label printing system.

134 ● A refined inventory record document was made according to the kind of drugs.

135 ● Dynamic physical inventory was performed daily, and static physical inventory  
136 combined with financial supervision was performed monthly.

137 ***Personnel management and Performance management***

138 ● A pre-job training was performed for each technician.

139 ● Professional knowledge training and assessment was performed weekly.

140 In addition, the personnel performance was associated with their performance  
141 assessment. The performance was fair and open, applying discipline, workload,  
142 quality of service, professional check, inventory and dispensing errors and work  
143 attendance as indicators for performance appraisal. The performance appraisal  
144 meeting was executed monthly and published the assessment results. In the meeting,  
145 we encouraged the employees to participate in the discussions and decisions with  
146 managers.

147 **“Check” stage**

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

150 **“Act” stage**

151 The achievement of each measures was analyzed. Successful measures were  
152 established as the standard, while the unsuccessful measures were formulated to a  
153 new round of improvement program next year.

154 After one year of management using PDCA cycle. The data of drug stocks,  
155 accounts and dispensing errors were analyzed using chi-square analysis and t-test. A  $p$   
156 value of less than 0.05 was considered significant.

## 157 **Results**

158 Medication safety is the core content of pharmaceutical management. The most  
159 concerned and difficult problem is to ensure that the drug is dispensed accurately and  
160 the stocks are consistent with the accounts.

### 161 **Stocks management**

162 In this study, we monitored the consistent rate of stocks and accounts before and  
163 after the implementation of a refined management of dispensation error prevention by  
164 PDCA cycle. As shown in Figure 3(A), the consistent rate of the stocks and accounts  
165 was 86.93% in 2008. Up to 2014, the consistent rate was increased to 99.13% ( $p <$   
166  $0.05$ ), showing remarkable results. From 2014 to 2019, the rates were all above 99%  
167 and reached to 99.54% ( $p < 0.05$ ) in 2019. Meanwhile, the error rate of inventory  
168 amount was also monitored (Figure 3(B)). In 2008, the error rate was 0.014%, which  
169 was quite severe due to such a high volume of medications. After the refined  
170 management for one year, the error rate was reduced to 0.005% ( $p < 0.05$ ), and by the  
171 year 2019, the error rate reduced to 0.0006% ( $p < 0.05$ ). The results indicated that the  
172 drug safety caused by dispensing errors greatly improved.

173 **Dispensing errors**

174 The implement of PDCA cycle significantly reduced the error rate of  
175 dispensation. As shown in Figure 3(C), the error rate was 0.019% in 2008.

176 However , by the year 2019, the number of prescription increased by 3.2 fold, while  
177 the error rate was significantly decreased to 0.000034%. This indicated that the  
178 measures significantly improve the awareness of drug safety for dispensing personnel.

179 **Target achieve rate and target improvement rate**

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

182 Target achievement rate =  $(\text{Rate}_{\text{after implementation}} - \text{Rate}_{\text{before implementation}}) / (\text{Rate}_{\text{target}} - \text{Rate}_{\text{before}}$   
183  $\text{implementation}) \times 100\%$

184 Target improvement rate =  $(\text{Rate}_{\text{after implementation}} - \text{Rate}_{\text{before implementation}}) / \text{Rate}_{\text{before}}$   
185  $\text{implementation} \times 100\%$

186 The evaluation results were listed in Table 1. From the results, the target  
187 achievement rate for rate of dispensing error, consistent rate of stocks and accounts, as  
188 well as error rate of inventory amount was 99.57%, 94.84% and 99.44%, respectively.

189 This indicated that implementation effect met the expectation. Besides, the target  
190 improvement rate for rate of dispensing error and error rate of inventory amount was  
191 99.57% and 99.44%, revealing that great progress has been made in this project.

192 **Personnel improvement**

193 In order to understand the improvement of staff capacity in this project, we

194 carried out a questionnaire survey for technicians before and after the project.  
195 According to the questionnaire results, the activity, responsibility, cohesion, problem-  
196 solving ability, communication ability and team cooperation ability for all technicians  
197 were evaluated and scored. Each technician had a maximum score of 5 points and a  
198 minimum score of 1 point for each item. Then, a radar map was drawn. It can be seen  
199 from Figure 4, the project has greatly improved the staff capacity for all technicians.

## 200 **Discussion**

201 Medication safety was incredibly important for patient safety. Studies from the  
202 UK and elsewhere have highlighted the prevalence of medication errors in primary  
203 care. Outpatient pharmacy in hospital was the direct contact department for patients  
204 after medical treatment. In WCH, we face a large number of patients every day, and a  
205 small management failure will lead to serious medical malpractice. Thus, an advanced  
206 and comprehensive management system was essential to ensure medication safety.  
207 Medication errors occur in all steps of the medication use process especially at the  
208 dispensing stages. Identify the problems in each step will help the managers to make  
209 rectification plan more effectively.

210 In recent years, PDCA cycle was widely used in hospital management. PDCA  
211 cycle was proposed by American management expert Deming in 1954 according to  
212 the information feedback principle. The PDCA cycle is performed in four stages:  
213 Plan-Do-Check-Act, so that the work quality can be improved in the continuous  
214 cycle.<sup>16, 28</sup> The application of PDCA in medicine management can not only  
215 significantly reduce the occurrence of adverse events, establish and effective

216 management system, strengthen the responsibility consciousness of pharmacists, but  
217 also improve the quality of clinical medication. In this study, we thoroughly analyzed  
218 the risk points affecting medication safety and summarize the major issues resulting in  
219 dispensing errors. Since the outpatient flow was huge in WCH, the workload of  
220 dispensing drugs was enormous. In this procedure, the technicians would inevitably  
221 feel tired, which may lead to abstracted or ignore the standard process. Besides, the  
222 new employees may be unfamiliar with the procedures and easily-confused drugs,  
223 which was also a potential risk for accurate dispensation. To solve this problem, we  
224 firstly divided the dispensing windows into six categories and applied a working shifts  
225 dynamic management to ensure that the number of technicians on duty matches the  
226 people flow in dispensing windows. This measure also ensured the time off for  
227 technicians and enable them to concentrate while working. In addition, a pre-job  
228 training and weekly professional knowledge training was performed for both old and  
229 new technicians to improve their technical skills.

230 Internal error record sheet was another innovation in this management. It was the  
231 last line of defense for dispensing errors. It happened after the moment the drug was  
232 dispensed and before the moment the drug was delivered to patients. This measure  
233 made the drug were double-checked by different technicians and guarantee the drug  
234 were correct when they were delivered to patients.

235 With many different kinds of drugs emerging on the market, some drugs are  
236 look-alike/sound-alike or have different specifications. These were very easily  
237 confused for technicians. Therefore, bold labels were applied for these drugs and a

238 principle of three-color and five-area classification was performed to standardize the  
239 drug display. These partitions and eye-catching logos can remind the technicians not  
240 to take the wrong medicine.

241 Consistent of stocks and accounts was an important index to evaluate if the  
242 medicine was dispensed correctly. Thus, a dynamic physical inventory was performed  
243 daily to examine the number of medicine and astatic physical inventory combined  
244 with financial supervision was performed monthly to examine the consistency of the  
245 account.

246 At the monthly meeting, each staff participated in the discussion of the problems,  
247 sharing what they had learned from work and improved dispensing error management  
248 system. Finally, after a year PDCA management, the data of drug stocks, accounts and  
249 dispensing errors were collected, analyzed and formulated a new round improvement  
250 procedure for unachieved issues. After the 12-year PDCA cycle management from  
251 2008 to 2019, the consistent rate of the stocks and accounts was significantly  
252 increased (86.93% vs 99.54%,  $p < 0.05$ ). The error rate of inventory amount was  
253 reduced (0.014% vs 0.0006%,  $p < 0.05$ ). At the same time, the rate of dispensing  
254 errors significantly reduced (0.019% vs 0.000034%,  $p < 0.05$ ). Besides, for personnel  
255 improvement, after the systematic management, the technicians have greatly  
256 improved the activity, responsibility, cohesion, problem-solving ability,  
257 communication ability and team cooperation ability. These results indicated that the  
258 PDCA cycle was a powerful tool for medication management in hospital outpatient  
259 pharmacy. However, further efforts should be made with observations, training and

260 raising awareness in order to increase the medication safety. error rate of dispensation.  
261 To our knowledge, this study was firstly reported a successful management  
262 experience of outpatient pharmacy in large hospital to improve medication safety by  
263 applying PDCA cycle.

## 264 **Conclusion**

265 Medication errors are the most common preventable cause of undesired adverse  
266 events in medication practice and present a major public health burden. Thus,  
267 improving the medication safety for patients was very important. Quality control  
268 works are important tools for technicians to promote drug safety awareness and  
269 medication skills. Investigation of the reasons for dispensing errors was helpful to  
270 implement the dispensing management. Besides, the PDCA cycle management mode  
271 was quite useful for hospital outpatient pharmacy without automatic dispenser.

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### 343 **Acknowledgments**

344 The authors disclosed receipt of the following financial support for the research,  
345 authorship, and/or publication of this article: This work was financially supported by  
346 the Regional Innovation Cooperation Project of Sichuan Science and Technology  
347 Department [grant number 2020YFQ0010] and the Health Commission of Sichuan  
348 Province [grant number 20PJ004].

### 349 **Ethics approval**

350 The data extracted in this study involves the drug inventory, drug accounts, the

351 number of dispensing errors recorded during the project and the performance of the

352 employees, which does not involve any of the patient, patient privacy and animals.

353 Ethical approval is not required for the study.

354

355 **Table 1** Target achievement rate and target improvement rate after project  
 356 implementation.

	Before implementation	Target value	After implementation	Target achievement rate	Target improvement rate
Rate of dispensing error (%)	0.018923	0	0.000081	99.57	99.57
Consistent rate of stocks and accounts (%)	86.93	100	99.33	94.84	14.25
Error rate of inventory amount (%)	0.01433	0	0.00008	99.44	99.44

357 **Figure legends**

358 **Figure 1** Fishbone diagram of risk points that affect medication safety.

359 **Figure 2** PDCA cycle.

360 **Figure 3** Consistent rate of stocks and accounts (A), error rate of inventory amount  
361 (B) and error rate of dispensation and number of prescription (C) from 2008 to 2019.

362 **Figure 4** Radar map of staff capacity change before and after the refined  
363 management.

364