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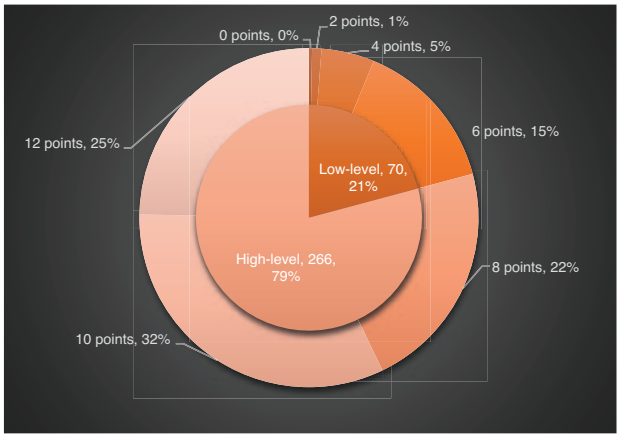
Research Article

Factors associated with pharmacists' knowledge regarding high-alert medications: a convenience sample survey in China

Graphical abstract



Highlights

- Several effective ways to enhance pharmacists' knowledge regarding high-alert medications were identified.
- Although pharmacists had good overall knowledge regarding high-alert medications, the knowledge was not fully applied to the process by which patients use high-alert medications.
- More attention should be paid to management aspects that are easily overlooked in the risk control of high-alert medications, such as drug recovery and destruction.

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In brief

Pharmacists' knowledge regarding high-alert medications was investigated through six questions. Each question was scored with 2 points. Pharmacists who scored 8 points or more were classified as having high knowledge, and those who scored 6 points or fewer were classified as having low knowledge. Almost 21% of the 336 pharmacists from southern, northern and central China had low knowledge regarding high-alert medications. Factors associated with knowledge regarding high-alert medications were analyzed. Several effective methods were identified to increase pharmacists' knowledge regarding high-alert medications, to improve the use of high-alert drugs and further assure drug safety for patients.

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Factors associated with pharmacists' knowledge regarding high-alert medications: a convenience sample survey in China

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ABSTRACT

The consequences of medication errors are more severe for high-alert medications than general drugs. Improving pharmacists' knowledge regarding high-alert medications is important to increase drug safety and maintain patient health. This study was aimed at understanding Chinese hospital pharmacists' knowledge regarding high-alert medications and exploring associated factors, to provide suggestions for management of high-alert medications. A total of 380 pharmacists from four hospitals in southern, northern and central China were selected through a convenience sampling method. Through a questionnaire survey, the pharmacists' demographic sociology characteristics and knowledge regarding high-alert medications were investigated. Chi-square tests and binary logistic regression were used to analyze the factors associated with pharmacists' knowledge regarding high-alert medications. A total of 336 valid questionnaires were returned, with an effective recovery rate of 88.4%. Among the respondents, 79.2% had high knowledge regarding high-alert medications. The analysis results show that the main factors significantly associated with pharmacists' knowledge levels of high-alert medication were work experience and professional title, whether high alert-medication knowledge was obtained through the network channel, whether high-alert-medication knowledge was obtained through daily work practice and whether high-alert medications were double independent checked before use. Increase the sharing of work cases and knowledge cooperation among different pharmacists and departments in high-alert medications, rationally adjust and arrange the responsibilities of pharmacists, and improve the internal circulation of hospital high-alert medications are helpful to improve pharmacists' cognitive level of high-alert medication and improve the hospital's ability to control the risk of high-alert medication.

Keywords: high-alert medication, knowledge level, risk control, pharmacists, China

1. INTRODUCTION

Drugs, which aid in the prevention and treatment of diseases, can both cure and cause diseases. According to a survey conducted by the Institute for Safe Medication Practices at the end of the 20th century, most cases of medication errors (MEs) that cause death or serious injury involve only a few specific drugs. Drugs that cause serious injury or death to patients with improper use are called "high-alert medications" (HAMs). Although MEs might not occur frequently, they are fatal if they do occur [1, 2]. Different definitions of HAMs exist but share the following characteristics: first, their pharmacological action is substantial and rapid, and thus they can easily harm the human body; second, the drugs themselves are highly toxic, and the adverse reactions are serious; third, HAMs have high-risk characteristics, such that their improper use can easily lead to serious consequences and even endanger life, harming not only patients but contact person.

Patient health harms caused by MEs have become a major factor threatening human health and safety in the 21st century. MEs are also the main cause of injuries due to the use of HAMs. In 1999, the Institute of Medicine released a survey report on patient safety in inpatient departments of American hospitals, which indicated that 44,000–98,000 hospitalized patients die from medical errors every year in the United States,

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ranking eighth among the top ten causes of death in the United States. These mistakes are avoidable. Approximately 1.5 million MEs in the United States occur every year, with an average of one ME per inpatient per day. Every year, 7,000 people die because of MEs [3]. A survey has indicated that approximately 1 in 30 patients receives preventable drug injuries in medical care, and more than one-quarter of these injuries are considered serious or life-threatening [4]. Silva et al. have examined the HAMs of hospitalized pediatric patients in Brazilian hospitals and found that 89.6% (632/705) involved incorrect prescriptions [5]. Thus, mistakes in providing HAMs, compared with common medicines, often have more severe consequences that may be devastating to patient health [6].

Developed countries and regions are paying increasing attention to the management of HAMs [7]. The Institute for Health Care Improvement in the United States has issued operational guidelines for the prevention of hazards related to HAMs, which describe specific health care interventions that can be undertaken by hospitals and/or entire health systems to improve the quality of health care [8]. In recent years, China has expanded a grass-roots team of clinical pharmacists and strengthened the training of clinical pharmacists. Many medical institutions have gradually understood the importance of HAM management, but no mandatory requirements have been established for HAMs. However, many problems persist in the current management of HAMs in China, such as the lack of a unified and effective management system and operation mode of standardized HAM circulation in medical institutions [9]. Because of the high risk of HAMs, HAM management in medical institutions primarily involves preventing HAMs from harming medical staff and patients in medical institutions. HAM risk control is important in risk management and is a new research field arising from risk assessment. For promoting drug safety, after the controlling subject fully identifies and evaluates the risks, various risk-management methods are optimized to ultimately decrease risks. HAM risk control is an important management method to prevent HAMs from causing serious harm to patients. Medical institutions often lack strict HAM management systems and standard operating procedures, thus resulting in potential safety hazards in HAM use and management. Medical staff may lack basic knowledge and understanding of HAMs. In one study among medical staff in a class III A children's hospital, the percentages of physicians, nurses and pharmacists able to accurately identify types of HAMs have been reported to be 6.70%, 21.24% and 25.38%, respectively [10]. Lack of knowledge and skills among medical staff regarding HAMs and fragmented management efforts making the entire medication process difficult, are important reasons for the frequent occurrence of adverse drug events [11, 12]. Few studies have focused on pharmacists' knowledge regarding HAMs in China. The roles of pharmacists in HAM risk control in hospitals has not received adequate attention. Moreover, studies have often been limited to the researchers' own hospitals or small areas, whereas relevant large-scale and holistic studies in China are lacking.

Therefore, this study was aimed at investigating the current status of pharmacists' understanding of HAMs, to ultimately improve pharmacists' knowledge and HAM management methods in medical institutions. This retrospective analysis of adverse events in HAMs may guide future prevention and control efforts, to preemptively decrease the potential controllable risks in HAMs, minimize possible injury to patients when drugs are used to treat diseases, regulate patients' physiological functions and promote HAM drug safety.

2. METHODS

This study combined qualitative and quantitative research methods, including literature research, empirical research, data analysis. The specific research methods are as follows.

2.1 Literature research methods

English databases such as Web of Science and PubMed were searched to identify literature on HAM risk control and to focus on the latest research progress in physicians' use and understanding of HAMs. Simultaneously, we consulted organizational websites, including those of the World Health Organization, to review their published information regarding HAMs, summarize the present status of HAM risk management and key factors affecting HAM security, and make attribution. The above information is summarized into the first edition questionnaire, which is revised and put into use after expert argumentation.

2.2 Empirical research methods

This survey was conducted both online and offline. With random sampling that did not affect hospital work, the survey was conducted among pharmacists in several hospitals (including TEDA International Cardiovascular Hospital, Guangdong Maternal and Child Health Hospital, Tongji Hospital, Tongji Medical College, Huazhong University of Science & Technology and Taihe Hospital and Affiliated Hospital of Hubei Medical University) in southern, northern and central China from 2016 to 2018.

2.3 Data analysis methods

SPSS 24.0 and Microsoft Excel (2016) were used for statistical analysis. After data collection, Epidata 3.1 software was used to enter the data, and Microsoft Excel (2016) was used to preliminarily sort the data. After exclusion of invalid data, the data finally included in the analysis were encoded and imported into SPSS 24.0 for descriptive statistical analysis. Beyond descriptive statistics, the main analytical methods included chi-square tests and binary logistic regression analysis with a test $\alpha$of 0.05 (two sided).

3. RESULTS

3.1 Basic status of survey participants

A survey was conducted on several hospitals in three regions of southern, northern and central China. With random sampling that did not affect work at the hospital, a total of 380 pharmacists were surveyed, and 336 valid questionnaires were collected. The effective rate of recovery was 88.4% (the criteria for valid questionnaires were filling time > 5 minutes and question completion rate ≥ 95.0%). The basic information on the investigated pharmacists is shown in Table 1.

Table 1 | Basic information on the investigated pharmacists.

Characteristics	Frequency (valid percentage)
Age (years)	
<30	138 (42.6%)
31–40	151 (46.6%)
> 40	35 (10.8%)
Missing	12
Gender	
Male	101 (30.3%)
Female	232 (69.7%)
Missing	3
Academic qualifications	
Below bachelor's degree	12 (3.6%)
Bachelor	234 (70.5%)
Master	85 (25.6%)
PhD	1 (0.3%)
Missing	4
Number of years of work	
0–5 years	157 (48.9%)
6–10 years	97 (30.2%)
11–15 years	28 (8.7%)
16 years or above	39 (12.1%)
Missing	15
Work department	
Clinical pharmacy	144 (51.1%)
Pharmacy department	133 (47.2%)
Hospital preparations	5 (1.7%)
Missing	54
Professional title	
Chief pharmacist	6 (1.8%)
Deputy chief pharmacist	30 (9.1%)
Head pharmacist	96 (29.0%)
Pharmacist	199 (45.6%)
Missing	5

3.2 Current status of risk control for high-alert medications

3.2.1 Status of high-alert medications used. In the survey, the frequency of HAM use was indirectly reflected by asking the pharmacist the time when Class A HAM appeared in the prescriptions recently reviewed. One case of unclear answer to this question was excluded in the statistical process. Class A HAMs mainly appeared in the prescriptions reviewed within 1 day (39.70%) or 1 week (20.00%), thus indicating that HAMs were used frequently.

In addition, half the pharmacists (52.08%) believed that HAMs, followed by combined drugs, often have dosage problems identified during prescription review.

3.2.2 Status of knowledge and learning regarding high-alert medications. A total of 336 pharmacists obtained HAM information and knowledge mainly through hospital documents or departmental regulations (61.60%), drug instructions (55.70%) and their daily work practice (45.80%). Several pharmacists (0.90%) had not been exposed to knowledge regarding HAMs.

Except that 3 respondents lacked information about training and education activities, HAM knowledge training and education activities in the hospitals where the pharmacists were located occurred mainly once per year (61.86%), followed by three or more times per year (18.62%), whereas overall training was more frequent. In some cases, pharmacists had never received HAM training conducted by hospitals.

3.2.3 Knowledge transfer regarding high-alert medications. Regarding the communication of HAM knowledge to patients, most (97.90%) pharmacists considered medication guidance necessary for patients receiving HAMs, but only 49.40% of pharmacists had provided patient guidance on how to use HAMs. Although the pharmacists were aware of the importance of HAM guidance for patients, such guidance was not implemented in practice. When general pharmacists distributed HAMs, most emphasized the drug administration route (74.70%), dose limitations (72.60%) and possible adverse reactions (69.60%).

Regarding the transmission of HAM knowledge among medical staff, most (99.4%) pharmacists believed that HAM guidance training should be conducted for other medical staff.

3.2.4 Risk control for high-alert medications. Overall, most pharmacists (95.54%) believed that their hospitals have average or good risk management of HAMs.

According to the statistics, pharmacists think that the management effect of drugs in all internal circulation links in hospitals is average. Medicine storage and drug blending were relatively well managed, whereas drug procurement, requests, recovery and destruction were relatively poor. These findings were consistent with the findings regarding risk management aspects that pharmacists thought must be strengthened. Medicine storage status was not considered to require strengthening; however, other aspects such as nurse's check of information, patient knowledge, knowledge and understanding of drug usage and dosage, and training and prescription screening needed to be strengthened.

From the hospital perspective, most (76.79%) pharmacists' hospitals gave warning prompt for prescriptions of class A HAMs, and most (87.50%) pharmacists' hospitals updated the HAM directory regularly. In addition, except that four respondents missed answering this question, approximately half (57.23%) of the pharmacists' hospitals had special personnel responsible for answering questions regarding the use of HAMs and providing counseling services to patients.

Almost all (91.37%) pharmacists performed a double-check of prescriptions and medicines before giving HAMs to patients. After exclusion of 19 questionnaires with incomplete information, the results indicated that 70.03% of pharmacists' job responsibilities included preparation of HAM solutions.

3.2.5 Medication errors for high-alert medications. Among 336 pharmacists, most (71.7%) had encountered no MEs for HAMs in the past year, 27.1% encountered one to three MEs for HAMs, and a smaller number encountered more than four MEs. The consequences of HAM MEs for patients are mainly that the problem is discovered before medications were used - almost causing harm (20.24%), and the patient has been used but has not caused harm - the patient's condition needs to be observed (6.25%). Notably, a considerable proportion of patients (9.23%) experienced serious harm or even death.

3.3 Pharmacists' knowledge of high-alert medications

In this study, to examine the pharmacists' knowledge regarding HAMs, we selected six topics regarding HAM knowledge, covering five areas: the concept of HAMs, taboos of commonly used HAMs, HAM usage, possible risks and drug treatments. Specific information and answers for each topic are shown in Table 2. Each question was scored with 2 points; no points were awarded for non-answers and incorrect answers. Scores of 8 points or above were classified as high knowledge, and scores 6 points or below were classified as low knowledge. The results were used to understand the pharmacists' knowledge regarding HAMs. The scores and groupings of pharmacists' HAM knowledge are shown

Table 2 | Questions and answers regarding pharmacists' knowledge of high-alert medications.

Field	Item	Options	Correct answer	Correct frequency	Missing	Correct rate
Concept	Which of the following descriptions of the concept of HAMs is correct?	1. Drugs that are frequently used 2. Drugs with high potential risk 3. Improper use of drugs that can cause serious injury or death to patients 4. Over-the-counter drugs requiring special attention	3	283	7	86.02%
Usage	Through which of the following routes of administration should vincristine be administered?	1. Intrathecal injection 2. Intravenous injection 3. Oral administration	2	259	2	77.54%
Usage	If norepinephrine spills out during intravenous injection, which drug should be used for treatment?	1. Phenobarbital 2. Phentolamine 3. Reserpine	2	273	2	81.74%
Contraindications	Which of the following is not a contraindication for the use of methotrexate?	1. Severely impaired liver function 2. Severe anemia 3. Thrombocytosis	3	195	2	58.38%
Potential risks	What are the potential serious risks of using magnesium sulfate injection?	1. Hypoglycemic shock 2. Respiratory muscle paralysis, halted breathing 3. Muscle cramps	2	240	1	71.64%
Potential risks	If insulin is overdosed or given to the wrong person, which of the following is most likely to occur?	1. Coma 2. Hyperglycemia 3. Paralytic stroke 4. Arrhythmia	1	273	0	81.25%

in Table 3. A total of 79.17% of the respondents had high understanding of HAMs in this study.

3.4 Analysis of single factors associated with pharmacists' knowledge

Chi-square tests were used to analyze the differences in sex, age, number of years of work, educational background, department, professional titles of pharmacists, access to HAM knowledge, HAM training education status and HAM risk management status, as they pertained to HAM knowledge. As shown in Table 4, no significant differences were observed in pharmacists' HAM knowledge according to sex, age, number of years of work, educational background, department, ways of obtaining knowledge regarding HAMs, frequency of training activities and HAM management details. However, significant differences were observed in professional titles, whether the network was used to obtain HAM knowledge, whether HAM knowledge was obtained through daily work and HAM risk management evaluation ($P<0.05$).

3.5 Analysis of multiple factors associated with pharmacists' knowledge

The pharmacists' knowledge regarding HAMs was used as a dependent variable, and the demographic characteristics of the pharmacists—including sex, age, number of years of work, educational background, department and title, methods of obtaining HAM knowledge, HAM training and education, HAM risk management and detailed HAM management specifications—were used as independent variables. The forward conditions were used for variable screening, and binary logistic regression analysis was performed. The forward conditional method is a forward method based on the estimation of conditional parameters, in which the independent variables are input into the equation in turn according to the score test probability, and then the removed variables are tested according to the conditional parameters. The results are shown in Tables 5 and 6. The main factors significantly associated with pharmacists' HAM knowledge were number of years of work, professional title, whether HAM knowledge was obtained through the network and daily work, whether HAM knowledge was obtained through external channels and whether HAMs were double-checked before use. The goodness-of-fit evaluation of the model indicated that the Nagelkerke R squared was 0.261 and the model has good adaptability.

Table 3 | Pharmacists' knowledge regarding high-alert medication scores and groupings.

Groups	Score	Frequency	Percentage (%)
Low-knowledge group	0	1	0.30%
	2	3	0.89%
	4	17	5.06%
	6	49	14.58%
	Total	70	20.83%
High-knowledge group	8	74	22.02%
	10	109	32.44%
	12	83	24.70%
	Total	266	79.17%

4. DISCUSSION

4.1 Pharmacists' HAM knowledge is acceptable, but needs to be translated into practical help for patients

According to the survey, the frequency of HAM use was relatively high, and problems regarding dosage and concomitant medication frequently occurred. Thus, the use of HAMs requires greater attention.

Regarding pharmacists' learning pertaining to HAMs, few pharmacists had inadequate knowledge regarding HAMs. The frequency of HAM training and education activities in the hospitals where the pharmacists worked occurred mainly once per year (61.81%), followed by three or more times per year (18.62%), thus indicating that the HAM training and education activities were performed frequently, and the hospitals provided pharmacists with opportunities to gain HAM knowledge. A total of 97.9% of pharmacists believed that medication guidance is necessary for patients who use HAMs, but only 49.4% of pharmacists had given such guidance; therefore, although pharmacists realize the importance of HAM guidance for patients, such guidance is seldom implemented in practice. In addition, most pharmacists (99.4%) considered that HAM training for other medical staff was needed. According to one survey, pharmacists had the highest average score of HAM understanding among medical staff; the clinical pharmacy staff had the highest scores, clinicians had the second-highest scores, and nursing staff had the lowest scores [13]. These findings indicated that HAM knowledge among other medical staff is lower than that of pharmacists; consequently, education and training are necessary for other medical staff, according to the pharmacist respondents. Continuing education is highly important to develop and update pharmacists' knowledge, skills and attitudes, and educational intervention can also strengthen the understanding of other medical personnel regarding HAMs [14-16]. According to the survey results, learning from hospital documents or department regulations, as well as drug instructions, might be effective ways to improve HAM knowledge among medical staff. HAM knowledge should be strengthened in school education for medical staff, and HAM training should be performed before work and during internships. Moreover, hospital documents and other related HAM knowledge education and training should be regularly provided to

Table 4 | Univariate analysis of pharmacists' knowledge regarding high-alert medications.

Items	Low-knowledge group		High-knowledge group		Chi-square	P
	N	N%	N	N%		
Sex					0.051	0.822
Male	22	31.43%	79	30.04%		
Female	48	68.57%	184	69.96%		
Age					5.913	0.052
< 30 years old	37	54.41%	101	39.45%		
30–40 years old	23	33.82%	128	50.00%		
>40 years old	8	11.76%	27	10.55%		
Number of years of work					5.501	0.139
0–5 years	39	58.21%	118	46.46%		
6–10 years	15	22.39%	82	32.28%		
11–15 years	3	4.48%	25	9.84%		
Over 16 years	10	14.93%	29	11.42%		
Educational background					5.941	0.115
Below bachelor	5	7.25%	7	2.66%		
Bachelor	52	75.36%	182	69.20%		
Master	12	17.39%	73	27.76%		
Doctor	0	0.00%	1	0.38%		
Department					1.571	0.456
Clinical pharmacy	31	54.39%	113	50.22%		
Pharmacy department	24	42.11%	109	48.44%		
Hospital preparation	2	3.51%	3	1.33%		
Professional title					25.093	0.000*
Pharmacy director	1	1.45%	5	1.91%		
Associate chief pharmacist	4	5.80%	26	9.92%		
Responsible pharmacist	12	17.39%	84	32.06%		
Pharmacist	30	43.48%	121	46.18%		
Assistant pharmacist	7	10.14%	16	6.11%		
Pharmacy worker	15	21.74%	10	3.82%		
Access to high-risk-drug knowledge						
Hospital documents or departmental regulations					2.862	0.091
False	33	47.14%	96	36.09%		
True	37	52.86%	170	63.91%		
Periodicals and magazines					2.781	0.095
False	61	87.14%	248	93.23%		
True	9	12.86%	18	6.77%		

Table 4 | Continued

Items	Low-knowledge group		High-knowledge group		Chi-square	P
	N	N%	N	N%		
Medicine specification					3.625	0.057
False	24	34.29%	125	46.99%		
True	46	65.71%	141	53.01%		
Academic conferences					2.014	0.156
False	58	82.86%	237	89.10%		
True	12	17.14%	29	10.90%		
Network					13.33	0.000*
False	56	80.00%	250	93.98%		
True	14	20.00%	16	6.02%		
Communication with peers					0.111	0.739
False	51	72.86%	199	74.81%		
True	19	27.14%	67	25.19%		
Pre-job training					0.624	0.43
False	58	82.86%	209	78.57%		
True	12	17.14%	57	21.43%		
Never obtained					1.561	0.111
False	68	97.14%	265	99.62%		
True	2	2.86%	1	0.38%		
Routine work					5.997	.0140*
False	47	67.14%	135	50.75%		
True	23	32.86%	131	49.25%		
Education of undergraduate and above					1.418	0.234
False	60	85.71%	241	90.60%		
True	10	14.29%	25	9.40%		
Continuing education					3.066	0.08
False	69	98.57%	244	91.73%		
True	1	1.43%	22	8.27%		
Frequency of training and education activities					1.225	0.747
Never	7	10.14%	27	10.23%		
Once per year	40	57.97%	166	62.88%		
Twice per year	6	8.70%	25	9.47%		
Three times per year or more	16	23.19%	46	17.42%		
Evaluation of risk management of HAMs					11.31	0.023*
Very poor	1	1.43%	4	1.51%		
Poor	3	4.29%	6	2.26%		
General	17	24.29%	89	33.58%		

Table 4 | Continued

Items	Low-knowledge group		High-knowledge group		Chi-square	P
	N	N%	N	N%		
Good	30	42.86%	136	51.32%		
Very good	19	27.14%	30	11.32%		
Regular updating of the list of HAMs					3.722	0.054
False	4	5.71%	38	14.29%		
True	66	94.29%	228	85.71%		
Double-check before the use of HAMs					0.311	0.577
False	7	10.00%	21	7.92%		
True	63	90.00%	244	92.08%		
Pharmacist is responsible for the preparation of high-risk-drug solutions					0.17	0.681
False	19	27.94%	76	30.52%		
True	49	72.06%	173	69.48%		

Table 5 | Binary logistic regression analysis of factors associated with pharmacists' knowledge regarding high-alert medications.

Variable	Reference variable	B	S.E.	Wald	P	OR	95% CI for OR	
							Lower	Upper
Number of years of work	Over 16 years			8.695	0.034			
0–5 years		2.124	0.882	5.798	0.016	8.367	1.485	47.152
6–10 years		2.34	0.823	8.075	0.004	10.376	2.067	52.1
11–15 years		2.542	1.144	4.941	0.026	12.704	1.351	119.501
Professional title	Pharmacy worker			17.853	0.003			
Pharmacy director		3.937	1.707	5.32	0.021	51.261	1.807	1454.312
Associate chief pharmacist		4.994	1.328	14.144	0	147.512	10.928	1991.124
Responsible pharmacist		2.944	0.819	12.924	0	18.987	3.815	94.501
Pharmacist		1.772	0.649	7.448	0.006	5.885	1.648	21.013
Assistant pharmacist		1.144	0.783	2.137	0.144	3.14	0.677	14.556
Access to high-risk-drug knowledge	False							
Network		-1.788	0.524	11.654	0.001	0.167	0.06	0.467
Routine work		0.746	0.348	4.611	0.032	2.109	1.067	4.168
Never obtained		-2.435	1.373	3.145	0.076	0.088	0.006	1.292
Double-check before the use of HAMs	False	-1.116	0.556	4.031	0.045	0.328	0.11	0.974
Constant		-1.559	1.135	1.887	0.17	0.21		

Table 6 | Average scores for understanding regarding high-alert medications in each group with statistical significance.

Items		Average of score
Number of years of work	0–5 years	8.7
	6–10 years	9.53
	11–15 years	9.79
	Over 16 years	8.92
Professional title	Pharmacy director	8.33
	Associate chief pharmacist	9.67
	Responsible pharmacist	9.65
	Pharmacist	9.07
	Assistant pharmacist	8.26
	Pharmacy workers	6.88
Network	False	9.2
	True	7.67
Routine work	False	8.73
	True	9.47
Never obtained	False	9.1
	True	5.33
Double-check before the use of HAMs	False	8.93
	True	9.07

medical staff in subsequent practical work, to consolidate their knowledge regarding HAMs and keep them abreast of new developments.

Most pharmacists and physicians agreed that drug consultation is the responsibility of pharmacists; thus high requirements exist for pharmacists to provide drug consultation services. The relevant knowledge of HAMs must be more fully conveyed when pharmacists distribute HAMs, to ensure patient safety, and to avoid and reduce the occurrence of HAM MEs [17].

4.2 HAM risk control is adequate, but attention must be paid to improving management aspects that are easily ignored

In terms of risk control for HAMs, most pharmacists considered the HAM risk management at their hospitals to be average or good. Pharmacists considered the management of drugs in all internal circulation links in hospitals to be average, and the drug storage and deployment to be relatively well managed. With the implementation of a HAM classification management strategy in China, HAM storage management may become stricter and more standardized, and a double-check system may be implemented in the drug deployment, thus making the drug storage and drug deployment relatively well managed [18]. The links of drug procurement, drug requisition, and drug recovery and destruction are relatively poor. Under insufficiently strict supervision, the drug market through which medications are procured results in uncertainties regarding drug quality and efficacy. In the usual asymmetric trading, buyers bear a greater risk burden than sellers [19]. As buyers, hospitals also face problems of drug quality and efficacy, thus potentially explaining why the pharmacists believed that the management of drug procurement links must be strengthened. At present, drug procurement, inventory management, drug requisition and other drug circulation links in many hospitals do not function efficiently, and a well-functioning drug management system has not yet been established [20]. The recovery of HAMs is not timely and adequate. Hospitals are recommended to build better hospital drug inventory management systems. Drug managers should also conduct regular drug inventories, recover and dispose of deteriorated and expired drugs in a timely manner, and report the drugs with low inventories to the procurement department [21]. From the perspective of hospitals, 76.79% of the pharmacists' hospitals have a warning on prescriptions containing class A HAMs, and 87.50% of the pharmacists' hospitals update the list of HAMs regularly. In this study, almost all (91.37%) pharmacists performed repeated examinations of prescriptions and medicines before providing HAMs to patients, and independent double examination has been found to play an important role in decreasing HAM MEs [22]. The implementation of HAM management measures in the hospitals was good, and both the hospitals and pharmacists had high awareness regarding HAM alerts, and took practical actions to promote rational use and medication safety regarding HAMs. However, some hospitals still must strengthen their risk control and management of HAMs, such as by establishing a HAM warning sign management system, using an electronic system to verify and issue a warning to the HAM prescription, in addition to regularly updating the HAM catalog. Of the 336 pharmacists, 27.1% had encountered MEs in HAMs. A considerable proportion (9.23%) of the MEs caused serious injury or even death to patients. Although most pharmacists did not encounter HAM MEs, owing to the characteristics of HAMs, after MEs occur, the harm to patients can be devastating [23].

4.3 Univariate and multivariate tests of pharmacists' knowledge regarding high-alert medications

Chi-square tests indicated that the pharmacists' professional titles, whether the network was used to obtain HAM knowledge, whether HAM knowledge was obtained through daily work and the hospital's HAM risk management evaluations were statistically significant ($P<0.05$), which means that these factors may be related to the HAM knowledge level of pharmacists. The analysis

indicated that demographic characteristics such as sex, age and educational background showed no significant association with pharmacists' knowledge. A possible reason for these findings might have been medical institutions' high educational requirements for pharmacists, and the pharmacists' long internships before starting formal work, which ensured that pharmacists had a clear understanding of their work and responsibilities, thus assuring the safety of patients' medications. The results regarding professional titles, whether the network was used to obtain HAM knowledge and whether HAM knowledge was obtained through daily work were essentially the same as the results of the multi-factor tests.

The results of binary logistic regression analysis indicated that number of years of work, professional titles, whether HAM knowledge was acquired through the network and daily work, whether HAM knowledge was acquired through external channels and whether HAMs were double verified before use were the main factors significantly associated with the pharmacists' knowledge regarding HAMs. Among pharmacists with 0–15 years' experience, older age was associated with greater understanding, possibly because the accumulation of work experience and long-term knowledge training continually increased pharmacists' HAM knowledge. However, the pharmacists who had worked for more than 16 years had the lowest understanding, possibly because older pharmacists might have had generally decreased memory and physical conditions, which led to a decline in understanding of HAMs. The HAM knowledge among chief pharmacists, deputy chief pharmacists, competent pharmacists, pharmacists and assistant pharmacists was higher than that of pharmacy workers. The understanding score of pharmacy workers was lowest, at 6.88 points, whereas that of chief pharmacists was 8.33 points. The low scores of chief pharmacists, which were below those of deputy chief pharmacists (9.67 points), competent pharmacists (9.65 points) and pharmacists (9.07 points), might have been due to their major duties having caused their work responsibilities to shift from clinical medication to focusing on the management of the pharmacy department. No significant differences were observed in the ways of obtaining HAM knowledge. In particular, the knowledge of pharmacists who obtained HAM knowledge through the network was lower than that of pharmacists who did not obtain HAM knowledge through the network, with OR=0.167 and P=0.001, thus indicating a negative correlation. A possible reason for this finding was that the network knowledge sources are complex, and distinguishing between true and false information is difficult. If the professional knowledge is insufficient, it is difficult to judge the authenticity of network knowledge, and it is easy to cause confusion and misleading. The Internet is not a good method to obtain information, because not all websites are trustworthy [24]. Pharmacists should select reliable information sources in acquiring knowledge regarding HAMs, and should identify the authenticity and reliability of the information. Obtaining more direct and accurate knowledge regarding HAMs through the rules and regulations promulgated by medical institutions and operational norms, or through the training of professional medical personnel, is preferable. The understanding of pharmacists who acquired HAM knowledge through their daily work was higher than that of pharmacists who did not acquire HAM knowledge through this channel, with OR=2.109 and P=0.032. This positive correlation might have been because work practice was a good learning method, in agreement with the single-factor and multi-factor results regarding professional titles and number of years of work. The knowledge level of pharmacists who have never obtained HAM knowledge through this channel was lower than that of pharmacists who had obtained this knowledge, with OR=0.088 P=0.076, thus indicating a negative correlation. Obviously, the knowledge level of pharmacists who acquire knowledge of HAM through some channels will increase. The knowledge of pharmacists who performed a double-check before using HAMs was lower than that of pharmacists who did not, with OR=0.328 P=0.045, thus indicating a negative correlation. In the double-check system, the second person might have relied on the conclusion of the first person, thus decreasing their thinking about and understanding of HAMs. In addition, the double-check system might also lead to confusion regarding the responsibilities of both parties, thereby resulting in low knowledge among pharmacists [25]. A flexible drug management mechanism should be established, and the work content of pharmacists should be appropriately adjusted in a timely manner to provide more opportunities for pharmacists to accumulate practice and experience, and improve their knowledge regarding HAMs.

In summary, the main factors significantly associated with pharmacists' HAM knowledge were number of years of work, professional title, whether HAM knowledge was obtained through the network and daily work, and HAMs were double-checked before use. The goodness-of-fit evaluation of the model showed a Nagelkerke R squared of 0.261, which explained 26.1% of the source of the difference and indicated that the main factors significantly associated with pharmacists' knowledge must be further explored.

5. CONCLUSION

In summary, the number of years of work and the accumulation of experience are the most effective entry point to improve pharmacists' understanding of HAMs. Older pharmacists with higher professional titles might have relatively less understanding of HAMs, because of objective factors such as aging and memory. In addition, the hospital management model may have problems in which improving efficiency decreases individual professional ability promotion.

The improvement of pharmacists' HAMs understanding and hospital HAM risk control cannot occur without the support and attention of hospital managers [26]. Pharmacists' HAM knowledge and hospital HAM risk control could be improved by increasing the sharing of work cases and knowledge cooperation among different pharmacists and departments in high-alert medications, rationally adjust and arrange the responsibilities of pharmacists, and improve the internal circulation of hospital high-alert medications. In addition, intra-professional cooperation with peers is an important source of information on HAMs. In the cooperation network, cross-professional cooperation among pharmacists and other medical personnel is crucial for HAM safety, and pharmacists should actively cooperate with other medical personnel in knowledge sharing, to improve the overall knowledge of medical personnel regarding HAMs, decrease potentially controllable risks related to HAMs and promote drug safety [27].

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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