DOI: 10.55415/deep-2022-0026.v1

A study on the factors influencing pharmacists' knowledge level in high-alert medication: a convenient sample survey in China

Ye Zhang[1] **Yuhang Zhaoa**[2] **Linhui Yang**[2] **Yuanxuan Cai**[2] **Xiaofang Shangguan**[2*] **Rui Huang**[2*]

[1]Department of Pharmacy, TEDA International Cardiovascular Hospital, Tianjin 300457, China

[2]School of Pharmacy, Tongji medical college, Huazhong University of Science and Technology, Wuhan 430030, Hubei, P. R. China.

*e-mail: shangguan.xf@foxmail.com; hys19810612@163.com

Funding This study was funded by National Natural Science Foundation of China (grant number 71874062) and Young Scientists Fund (grant number 71503089).

DOI: 10.55415/deep-2022-0026.v1

Abstract

Background Compared with general drugs, the consequences of errors in high-alert medication are more severe. Improving pharmacists' knowledge level of high-alert medication is of great significance for improving drug safety and maintaining patients' health. **Objective** To understand the current situation of Chinese hospital pharmacists' knowledge level of high-alert medication and explore its influencing factors, so as to provide management suggestions for high-alert medication. **Methods** 380 pharmacists from four hospitals in south, north and central China were selected by convenient sampling method. Through questionnaire survey, the characteristics of demographic sociology and the status quo of knowledge level in high-alert medication were investigated. Chi-square test and Binary Logistic regression were used to analyze the influencing factors of pharmacists' knowledge level in high-alert medication. **Results** A total of 336 valid questionnaires were recovered, with an effective recovery rate of 88.4%. Among the respondents, 79.2% have a high level of high-alert medication knowledge. The analysis results show that work experience and professional title, whether to obtain high-alert medication knowledge through the network, whether to obtain high-alert medication knowledge through daily work, whether the knowledge of high-alert medication is obtained through external channels, and whether the knowledge of high-alert medication is re-examined before use are the main factors affecting pharmacists' knowledge level of high-alert medication. **Conclusion** Increasing work case sharing and knowledge cooperation, rationally arranging the work scope of each pharmacist, and improving the hospital management mode 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.

Key words High-Alert Medication; Knowledge Level; Risk Control; Pharmacists; China

DOI: 10.55415/deep-2022-0026.v1

1. INTRODUCTION

As a special commodity for the prevention and treatment of diseases, drugs have the dual characteristics of curing diseases and possibly causing diseases. According to a survey conducted by the Institute for Safe Medication Practices (ISMP) 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. Therefore, drugs that cause serious injury or death to patients due to improper use are called “high-alert medication”(HAM). Such errors may not happen frequently, but once they happen, they are fatal [1,2]. Although different scholars have different definitions of HAM, they mainly have the following understandings: First, the pharmacological action is remarkable and rapid, and it is easy to cause harm to human body; second, the drug itself is highly toxic, and its adverse reactions are serious； third, HAM have the characteristics of high risk, that is, improper use can easily lead to serious consequences and even endanger life, and harm is not only for patients, but also for contacts.

Patient health damage caused by medication errors has become a major factor threatening human health and safety in the 21st century, and MEs are also the main cause of injuries caused by the use of high-alert medication. In 1999, the Institute of Medicine (IOM) released a survey report on patient safety in inpatient departments of American hospitals. It pointed out that 44,000–98,000 hospitalized patients die from medical errors every year in the United States, ranking eighth in the mortality rate. We could have avoided these mistakes. There are about 1.5 million MEs in the United States every year, with an average of one MEs per inpatient every day. Every year, 7,000 people die due to MEs [3].A survey also have shown that one in about 30 patients receives preventable drug injuries in medical care, and more than a quarter of such injuries are considered serious or life-threatening [4]. Silva et al. examined the HAM of hospitalized pediatric patients in Brazilian hospitals and found that

DOI: 10.55415/deep-2022-0026.v1

89.6% (632/705) of the HAM were incorrectly prescribed [5]. In a word, compared with common medicines, the mistakes in HAM often bring more severe consequences, which may be devastating to the health of patients [6].

At present, developed countries and regions pay more and more attention to the management of HAM [7]. The Institute for Health Care Improvement (IHI) of the United States has issued operational guidelines for the prevention of hazards in HAM, which describe specific health care interventions that can be taken by hospitals and/or the entire health system to improve the quality of health care [8]. In recent years, China has expanded the grass-roots team of clinical pharmacists and strengthened the training of clinical pharmacists. Many medical institutions have gradually realized the importance of high-alert medication management, but there is still no mandatory requirement for HAM. However, there still exist many problems in the current management of HAM in China. Such as the lack of specific laws and regulations to guide and manage HAM, as well as a unified and effective management system and operation mode [9]. Based on the high risk of HAM, the core of HAM management in medical institutions is to control the possibility of HAM causing harm to medical staff and patients in the internal circulation of medical institutions. HAM risk control is an important research content of risk management, and it is a brand-new research field extended from risk assessment. For promoting drug safety, after controlling the subjects to identify and evaluate risks, various risk treatment technologies are optimized, and the risks are ultimately reduced. HAM risk control is an important management means to avoid HAM causing serious harm to patients. Medical institutions lack strict HAM management system and standard operating procedures, resulting in potential safety hazards in the use and management of HAM. The medical staff were lack of basic knowledge and cognition about HAM, the percentages of physicians, nurses and pharmacists who

DOI: 10.55415/deep-2022-0026.v1

could accurately identify the varieties of HAM among medical staff in a class III A children's hospital were 6.70%, 21.24% and 25.38%, respectively [10]. The lack of knowledge and skills of medical staff in HAM and the fragmented management in HAM, which are difficult to run through the whole medication process, are important reasons for the frequent occurrence of adverse drug events [11,12].

Therefore, it is necessary to investigate the current situation of pharmacists' high-alert medication cognition, seek effective means to improve pharmacists' knowledge level of HAM and improve the management methods of HAM in medical institutions. To prevent or reduce the potential controllable risks of HAM, and minimize the possible harm that patients may suffer when using drugs to treat diseases and adjust their physiological functions. Besides, to change the retrospective analysis of adverse events in HAM into prevention and control in advance, to promote drug safety in HAM.

2. METHODS

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

2.1 Literature research method

Search English databases such as Web of Science and Pubmed to collect information on risk control of HAM-related literature, and focus on the latest research progress of doctors' use and cognition of HAM. At the same time, consult websites of the World Health Organization (WHO) and other websites, check the information related to HAM published by them, summarize the present situation of HAM risk management report and key factors affecting HAM security, and make attribution. The whole is the first version of the questionnaire.

DOI: 10.55415/deep-2022-0026.v1

2.2 Empirical research method

Based on the principle of random sampling and without affecting the hospital work, the survey was conducted among pharmacists in a number of 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， Affiliated Hospital of Hubei Medical University) in south, north and middle regions of China from 2016 to 2018.

2.3 Data analysis method

Use SPSS 24.0 and Microsoft Excel (2016) for statistical analysis. After data collection, use Epidata 3.1 software to enter the data, and use Microsoft Excel (2016) to sort the data preliminarily. After excluding invalid data, encode the data finally included in the analysis, and import it into SPSS 24.0 for descriptive statistical analysis. Besides descriptive statistics, the main analytical methods included Chi-square test and Binary Logistic regression analysis. Assume that the test α is 0.05 (bilateral).

3. RESULTS

3.1 Basic situation of survey subjects

A survey was conducted on a number of hospitals in three regions of southern, northern and central China. Based on random sampling Principles, and without affecting the work of the hospital, a total of 380 pharmacists were surveyed, and 336 valid questionnaires were collected. The effective rate of volume recovery is 88.4% (valid questionnaire judgment criteria: filling time> 5 minutes,

DOI: 10.55415/deep-2022-0026.v1

question completion rate ≥ 95.0%). The basic information of the investigated pharmacists is shown in Table 1.

Table 1 The basic information of the investigated pharmacists

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

3.2 Current situation of risk control in high-alert medication

3.2.1 The situation of high-alert medication used

Through the time to occurrence of Class A high-alert medication in a recently reviewed prescription to indirectly reflect the frequency of use of HAM, and the statistical process excluded 1 case with unknown information. The results showed that Class A high-alert medication mainly

DOI: 10.55415/deep-2022-0026.v1

appeared in one day (39.70%) or one week (20.00%), indicating that HAM was used more frequently.

In addition, half of the pharmacists (52.08%) believe that HAM most often has dosage problems during prescription review, followed by combined drugs.

3.2.2 The situation of high-alert medication knowledge learning

336 pharmacists obtained the information and knowledge of HAM mainly through hospital documents or department regulations (61.60%), drug instructions (55.70%) and daily work practice (45.80%). A few pharmacists (0.90%) had not been exposed to the knowledge of HAM.

Except for three cases whose information was not available, the frequency of HAM knowledge training and education activities in the hospital where the pharmacist was located was mainly once a year (61.86%), followed by three or more times a year (18.62%), and the overall training was more frequent. There are cases where pharmacists have never received HAM training conducted by hospitals.

3.2.3 Knowledge Transfer of high-alert medication

Regarding the communication of patients' HAM knowledge, the vast majority (97.90%) of pharmacists considered it necessary to provide medication guidance to patients using HAM, but only 49.40% of pharmacists had provided guidance to patients on how to use HAM. Although pharmacists are aware of the importance of HAM guidance for patients, it has not been implemented in the practice process. When general pharmacists distribute HAM, most of them will emphasize the drug administration route (74.70%), dose limitation (72.60%) and possible adverse reactions (69.60%).

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

DOI: 10.55415/deep-2022-0026.v1

3.2.4 Risk control of high-alert medication

Overall, most pharmacists (95.54%) believe that their hospitals do general or good risk management of HAM.

According to the statistics, pharmacists believed that the management of internal circulation links in drug hospitals was generally effective. Medicines storage and drug blending were relatively well managed, while drug procurement, drug request, drug recovery and destruction were relatively poor. This was consistent with the results of risk management links that pharmacists thought need to be strengthened. It was considered that the medicines storage situation was relatively not need to be strengthened, but the aspects such as nurse information check, patient knowledge, drug usage and dosage knowledge understanding and training, and prescription screening needed to be strengthened.

From the hospital perspective, most (76.79%) of pharmacists' hospitals would give warning signs for prescriptions containing class A HAM, and the vast majority (87.50%) of pharmacists' hospitals would update the HAM directory regularly. In addition, except for four questionnaires with unknown information, only about half (57.23%) of pharmacists' hospitals were equipped with special personnel responsible for answering questions about the use of HAM and providing counseling services to patients.

From the perspective of pharmacists, almost all (91.37%) pharmacists performed double check before using HAM on patients. Excluding 19 questionnaires with incomplete information,70.03% of pharmacists' job responsibilities included preparation of HAM solution.

3.2.5 Medication errors of high-alert medication

Among 336 pharmacists, the majority (71.7%) had no medication errors in HAM in the past year,

DOI: 10.55415/deep-2022-0026.v1

27.1% had one to three medication errors in HAM, and a lesser number of more than 4 times. The main consequences for patients due to medication errors of HAM are that problems are discovered before the medication is used, almost causing harm (20.24%), and the medication has been used but no harm has yet been caused. Observation is needed (6.25%). It is worth noting that a considerable part (9.23%) caused serious harm or even death to patients.

3.3 Knowledge level of high-alert medication of pharmacists

In this study, six topics about HAM knowledge were selected, covering five areas in total, including the concept of HAM, commonly used tight taboos of HAM, usage, possible risks and treatment drugs to examine the pharmacists' knowledge level of HAM. Each question 2 points, the question will be considered as 0 points for non-answer and wrong answer. Those who got 8 points or above were classified as high-level knowledge group and those who got 6 points or below were classified as low-level knowledge group. All these were used to understand the cognitive status of pharmacist HAM. The scores and groupings of pharmacist HAM's knowledge were shown in Tables 2. It considered that 79.17% of the respondents had a high cognition level of HAM in this study.

Table 2 The pharmacists' knowledge of high-alert medication scores and groupings

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

DOI: 10.55415/deep-2022-0026.v1

3.4 Single factor analysis of influencing pharmacists' knowledge level

The Chi-square test was used to analyze the differences of gender, age, working years, educational background, department, professional title of pharmacists, and access to HAM knowledge, training education situation of HAM and risk management situation of HAM in the knowledge level of HAM. As shown in Table 3, there were no significant differences in the level of knowledge of pharmacist HAM from gender, age, working years, educational background, department, most of the ways to obtain knowledge of HAM, the frequency of training activities, and the management details of HAM. However, there were significant differences in the professional title, whether to use the network to obtain knowledge of HAM, whether to obtain knowledge of HAM through daily work, and the risk management evaluation of HAM ($P<0.05$).

Table 3 Univariate analysis of pharmacists' knowledge level of high-alert medication

Items		Low knowledge level group		High knowledge level group		Chi-square	P
		N	N %	N	N %		
Gender						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%		
Years of working						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
	Bellow 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

DOI: 10.55415/deep-2022-0026.v1

	Clinical pharmacy	31	54.39%	113	50.22%		
	Pharmacy department	24	42.11%	109	48.44%		
	Hospital preparations	2	3.51%	3	1.33%		
Professional title						25.093	0.000*
	Director of the pharmacist	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 workers	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%		
Medicine specification						3.625	0.057
	False	24	34.29%	125	46.99%		
	True	46	65.71%	141	53.01%		
Academic conference						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 get						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%		

DOI: 10.55415/deep-2022-0026.v1

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 a year	40	57.97%	166	62.88%	
	Twice a year	6	8.70%	25	9.47%	
	Three times a year or more	16	23.19%	46	17.42%	
Evaluation of risk management of HAM					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%	
	Good	30	42.86%	136	51.32%	
	Very good	19	27.14%	30	11.32%	
Whether the list of HAM is updated regularly					3.722	0.054
	FALSE	4	5.71%	38	14.29%	
	TRUE	66	94.29%	228	85.71%	
Whether there is a double check before the use of HAM					0.311	0.577
	FALSE	7	10.00%	21	7.92%	
	TRUE	63	90.00%	244	92.08%	
Whether the pharmacist is responsible for the preparation of high-risk drug solution					0.17	0.681
	FALSE	19	27.94%	76	30.52%	
	TRUE	49	72.06%	173	69.48%	

3.5 Analysis of multi-factors affecting knowledge level of pharmacists

The knowledge level of pharmacists in HAM was taken as a dependent variable, and demographic characteristics of pharmacists, including gender, age, working years, educational background, department, and title, as well as the way to obtain knowledge about HAM, training and education in HAM, risk management in HAM, and detailed management specifications in HAM, were taken as independent variables. The forward conditions were used for variable screening and Binary Logistic regression analysis was performed. The results were as shown in Table 4 and Table 5. The main factors affecting the knowledge level of pharmacist HAM were working years, professional

DOI: 10.55415/deep-2022-0026.v1

title, whether to obtain HAM knowledge through network and daily work, whether to obtain HAM knowledge through external channels, and whether to double-check HAM before use. The goodness-of-fit evaluation of the model showed that Nagelkerke R Square was 0.261, accounting for 26.1% of the source of the difference.

Table 4 Binary Logistic regression analysis of influencing factors of pharmacists' knowledge level of high-alert medication

Variable	Reference variable	B	S.E.	Wald	P	OR	95% CI for OR	
							Lower	Upper
Years of working	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 workers			17.853	0.003			
Director of the pharmacist		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 get		-2.435	1.373	3.145	0.076	0.088	0.006	1.292
Whether there is a double check before the use of HAM	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 5 Average score of cognitive level of high-alert medication in each group with statistically significant.

Items	Average of score

DOI: 10.55415/deep-2022-0026.v1

Years of working	0-5 years	8.7
	6-10 years	9.53
	11-15 years	9.79
	Over 16 years	8.92
Professional title	Director of the pharmacist	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 get	False	9.1
	True	5.33
Whether there is a double check before the use of HAM	False	8.93
	True	9.07

4. DISCUSSION

4.1 Pharmacists' HAM knowledge level is acceptable, but need to strengthen the transformation to the actual help to the patient

According to the survey, the use frequency of HAM was relatively high, and the problems of dosage and concomitant medication often occurred. It shows that the use of HAM needs more attention.

Regarding knowledge learning of pharmacists in HAM, Few pharmacists did not understand the knowledge of HAM. The frequency of training and education activities on HAM in the hospital where pharmacists work was mainly once a year (61.81%), followed by three or more times a year (18.62%), indicating that the training and education activities on HAM knowledge were carried out frequently, and the hospital provided pharmacists with better opportunities to learn HAM knowledge. 97.9% of

DOI: 10.55415/deep-2022-0026.v1

pharmacists think it is necessary to give medication guidance for patients who use HAM, but only 49.4% of pharmacists have given guidance for them, which shows that although pharmacists realize the importance of HAM guidance for patients, it is seldom implemented in practice. In addition, the majority of pharmacists (99.4%) considered that HAM instruction training for other medical staff was needed. According to one survey result, the pharmacists had the highest average score of HAM cognition among medical staff, and the clinical pharmacy staff had the highest score， the second was clinicians, and the nursing staff had the lowest score [13]. Continuing education (CE) is very important to develop and update the knowledge, skills and attitudes of pharmacists, and educational intervention can also strengthen the understanding of other medical personnel on HAM [14-16]. It is suggested that HAM knowledge should be strengthened in school education for medical staff, HAM knowledge training should be carried out before work and during internship, and HAM knowledge education and training should be regularly conducted for medical staff in subsequent practical work so as to consolidate their knowledge level in HAM and follow up the latest progress in HAM.

Most pharmacists and doctors agree that drug consultation is the responsibility of pharmacists, which puts forward higher requirements for pharmacists to provide drug consultation services. The relevant knowledge information of HAM needs to be more fully conveyed when pharmacists distribute HAM, to ensure the safety of patients' medication, and to avoid and reduce the occurrence of medication errors in HAM [17].

4.2 HAM risk control in good condition, but need to pay attention to improve the management links that are easy to be ignored

In terms of risk control for HAM, most pharmacists considered the risk management in HAM of their hospitals as average or good. Pharmacists considered the internal circulation management in

DOI: 10.55415/deep-2022-0026.v1

drug hospitals as average, with the drug storage and drug deployment relatively well managed. It is possible that with the implementation of the HAM classification management strategy in China, the storage management of HAM is stricter and more standardized, and the double check system is implemented in the drug deployment link, which makes the drug storage and drug deployment link relatively well managed [18]. The links of drug procurement, drug requisition, drug recovery and destruction are relatively poor. Under the condition of not strict supervision, drug trading has uncertainty of drug quality and efficacy. In the usually asymmetric trading, buyers bear a greater risk burden [19]. As buyers, hospitals also face problems of drug quality and efficacy, which may be the reason why pharmacists believe that the management of drug procurement links needs to be strengthened. At present, drug procurement, inventory management, drug requisition and other drug circulation links in many hospitals are not smooth enough, and a smooth drug management system has not yet been formed [20]. The recovery of HAM is not timely and adequate. It is recommended that hospitals build a more perfect hospital drug inventory management system. Drug managers should also conduct regular inventory of drugs, timely recover and dispose deteriorated and expired drugs, and report the drugs with small inventory to the procurement department, which should purchase drugs according to the principle of "right amount and multiple times" in the process of drug procurement [21]. From the perspective of hospitals, 76.79% of pharmacists' hospitals would warn prescriptions containing HAM of Class A, and 87.50% of pharmacists' hospitals would update the list of HAM regularly. From the perspective of pharmacists, almost all (91.37%) pharmacists performed repeated examinations before applying HAM to patients, and independent double examination played an important role in reducing medication errors of HAM [22]. The system showed that the implementation of management measures in HAM of the hospital was good, and both the hospital and

DOI: 10.55415/deep-2022-0026.v1

pharmacists had high awareness of HAM alert, and would take practical actions to promote the rational use and medication safety in HAM. Of the 336 pharmacists, 27.1% had a history of medication errors in HAM. A considerable part (9.23%) of the consequences of medication errors caused serious injury or even death to patients. Although most pharmacists did not make medication errors in HAM, due to the particularity of HAM, once HAM made medication errors, the damages to patients could be devastating [23].

4.3 Univariate and multivariate tests influencing knowledge level of pharmacists on high alert medication

The result of Chi-square test shows that the professional title, whether to use the network to obtain HAM knowledge, whether to obtain HAM knowledge through daily work, and the risk management evaluation of hospital HAM were statistically significant ($P<0.05$). The above analysis results show that the demographic characteristics such as gender, age, education background had no significant influence on the knowledge level of pharmacists. The possible reason is that the higher requirement of medical institutions for pharmacists' education background and the longer internship time before starting formal work, so as to ensure that pharmacists had a clear understanding of their work contents and responsibilities, and thus to ensure the safety of patients' medication. The results of professional title, whether to use the network to obtain HAM knowledge, and whether to obtain HAM knowledge through daily work were basically the same as the results of multi-factor test.

The results of Binary Logistic regression analysis showed that working years, professional titles, whether HAM knowledge was acquired through the network and daily work, whether HAM knowledge was acquired through external channels, and whether HAM double checked before use were the main factors affecting the knowledge level of HAM of pharmacists. Among them, for

DOI: 10.55415/deep-2022-0026.v1

pharmacists with working experience of 0-15 years, the higher the age group was, the higher the cognition level was. This might be due to the accumulation of work experience, long-term knowledge training and so on, which made the knowledge level of pharmacist HAM continuously, improve. The pharmacists who had worked for more than 16 years had the lowest cognitive level, which might be due to the generally high age, decreased memory and physical condition of pharmacists who had worked for more than 16 years, which led to the decline of cognitive level of HAM. The HAM knowledge levels of chief pharmacist, deputy chief pharmacist, competent pharmacist, pharmacist and assistant pharmacists were relatively high relative to that of pharmacy workers. The cognitive level score of pharmacy workers was the lowest (6.88 points), and that of chief pharmacist was 8.33 points. Below the scores of deputy chief pharmacists (9.67 points), competent pharmacists (9.65 points) and pharmacists (9.07 points), the knowledge level of chief pharmacists might be due to their major duty, which caused their work responsibilities to shift from clinical medication to focus on the management of pharmacy department, and consequently led to their low scores. There was no significant difference in the ways of obtaining various HAM knowledge. In particular, the level of knowledge of HAM obtained through the network was relatively low compared with that of pharmacists who did not obtain knowledge of HAM through the network, with OR = 0.167 and P = 0.001, indicating a negative correlation. The possible reason was that the network knowledge was complex and it was difficult to distinguish between true and false. It was difficult to judge if the professional knowledge was insufficient, but it was easy to cause confusion and misleading. The Internet is not a good way to get information because not all websites are trustworthy [24]. It was suggested that pharmacists should select reliable information sources when acquiring the knowledge of HAM, and pay attention to identify the authenticity and reliability of information. It was best to obtain more direct and

DOI: 10.55415/deep-2022-0026.v1

accurate knowledge of HAM through the rules and regulations promulgated by medical institutions and operational norms, or through the training of professional medical personnel. The cognitive level of pharmacists who acquired knowledge of HAM through daily work was higher than that of pharmacists who did not acquire knowledge of HAM through this channel, OR = 2.109, and P = 0.032. This shows a positive correlation, which might be because work practice was a good learning method and could be coordinated with the single-factor and multi-factor results of professional title and working life. The level of knowledge about HAM that pharmacists had never obtained through this channel was lower than that of pharmacists who had obtained this knowledge, with OR= 0.088 P =0.076, showing a negative correlation. It was obvious that the cognitive level of pharmacists who had obtained HAM knowledge would be improved. The knowledge level of pharmacists who performed double check before using the HAM was lower than that without it, OR= 0.328 P =0.045, and there was a negative correlation. Perhaps because of the double check system, the second person would rely on the conclusion of the first person to reduce their thinking and understanding of HAM. In addition, the double check system could also lead to confusion of responsibilities of both parties, which in turn led to the low knowledge level of pharmacists [25]. It was suggested that flexible mechanism-based drug management should be established and the work content of pharmacists should be appropriately adjusted in time to provide more opportunities for pharmacists to accumulate practice and experience, to improve their knowledge level of HAM.

In summary, the main factors affecting the knowledge level of pharmacist HAM were working years, professional title, whether to obtain HAM knowledge through the network and daily work, whether to obtain HAM knowledge through external channels, and whether to double-check HAM before use. The goodness-of-fit evaluation of the model showed that Nagelkerke R Square was 0.261,

DOI: 10.55415/deep-2022-0026.v1

which explained 26.1% of the source of the difference, and indicated that there were some main factors affecting the knowledge level of pharmacists that needed to be further explored.

5. CONCLUSION

In summary, working years and experience accumulation are the most effective ways to improve the cognition of pharmacist HAM. Older pharmacists with high professional titles may have relatively decreased cognition in HAM due to objective factors such as body and memory. In addition, the hospital management model may have the problem of improving efficiency while reducing individual promotion opportunities.

The improvement of pharmacists' HAM cognitive level and the improvement of hospital HAM risk control cannot be separated from the support and attention of hospital managers [26]. It was suggested that the cognition level of pharmacist HAM could be improved and hospital HAM risk control could be perfected by increasing work case sharing, reasonably arranging the work scope of each pharmacist, and improving hospital management mode. In addition, intra-professional cooperation with peers was an important source channel for information on HAM. In the cooperation network, pharmacists were considered to be the most important cross-professional cooperation objects for the safety of HAM , and it was recommended that pharmacists actively cooperate with other medical personnel in the form of knowledge sharing, so as to improve the overall knowledge level of medical personnel on HAM , reduce the potential controllable risks in HAM, and promote drug safety in HAM [27].

Acknowledgements: Thanks to TEDA International Cardiovascular Hospital, Guangdong Maternal

and Child Health Hospital, Tongji Hospital, Tongji Medical College, Huazhong University of Science & Technology, and Taihe Hospital, Affiliated Hospital of Hubei Medical University for their support and help during the investigation.

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

References:

[1] Julie S, Jeffrey MN, Krystin D. Severity of medication administration errors detected by a bar-code medication administration system. *American Journal of Health-System Pharmacy* 2008;65(17).

[2] Daniel FM, Christopher RF, Kelli LG. Bar Code Medication Administration Technology: Characterization of High-Alert Medication Triggers and Clinician Workarounds. *Annals of Pharmacotherapy* 2011;45(2).

[3] Kohn et al. *To err is human*: National Academy Press; 2000. ISBN : 0309068371

[4] Hodkinson A, Tyler N, Ashcroft DM, et al. Preventable medication harm across health care settings: a systematic review and meta-analysis. *BMC MEDICINE* 2020;18(1).

[5] Silva MDDG, Rosa MB, Franklin BD, Reis AMM, Anchieta LM, Mota JAC. Concomitant prescribing and dispensing errors at a Brazilian hospital: a descriptive study. *Clinics (Sao Paulo, Brazil)* 2011;66(10).

[6] Michael RC. Risk models to improve safety of dispensing high-alert medications in community pharmacies. *Journal of the American Pharmacists Association* 2012;52(5).

[7] Elizabeth S, Sondra M. JCAHO Med Management - Managing High-Risk Medications: Implementing Medication Management Standard 7.10. *Hospital Pharmacy* 2006;41(5).

[8] How-to Guide: Prevent Harm from High-Alert Medications | IHI - Institute for Healthcare Improvement. Vol 20212021.

[9] Hui Y, et al., Present situation and development trend of the management specialty of high-risk medication--Discussion on the physician's responsibility in high-risk medication management *Medical Journal of Chinese People's Liberation Army* 2014;39(02):89-93. (in Chinese)

[10] Lei W, Xuan W. Analysis of medical staff's cognition status and influencing factors of high warning drugs in a third-class A children's hospital. *Anhui Medical Journal* 2021;42(03):332-335. (in Chinese)

[11] Phillips J, Beam S, Brinker A, et al. Retrospective analysis of mortalities associated with medication errors. *Am J Health Syst Pharm* 2001;58(19):1835-1841.

[12] Hsaio G-Y, Chen IJ, Yu S, Wei I-L, Fang Y-Y, Tang F-I. Nurses' knowledge of high-alert medications: instrument development and validation. *JOURNAL OF ADVANCED NURSING* 2010;66(1):177-190.

[13] Meng K, Research of risk-control mechanism of high-alert medications in hospitals in China, *Master Thesis*. Huazhong University of Science and Technology，School of Pharmacy；2019.

[14] Terajima T, Matsushita K, Yamada S, et al. Perspectives on Continuing Education Programs for Foundation-Level Drugstore Pharmacists in Japan. *PHARMACY* 2020;8(4).

[15] Lu M-C, Yu S, Chen IJ, Wang K-WK, Wu H-F, Tang F-I. Nurses' knowledge of high-alert medications: A randomized controlled trial. *NURSE EDUCATION TODAY* 2013;33(1):24-30.

[16] Alhaqan A, Smith F, Bates I. A global evidence review of systemic factors influencing participation in pharmacy professional development activities. *RESEARCH IN SOCIAL & ADMINISTRATIVE PHARMACY* 2021;17(3):488-496.

[17] Al-Hashar A, Al-Zakwani I, Eriksson T, Al Za'Abi M. Whose responsibility is medication reconciliation: Physicians, pharmacists or nurses? A survey in an academic tertiary care hospital. *SAUDI PHARMACEUTICAL JOURNAL* 2017;25(1):52-58.

[18] Rong B et al., Research on Management Mode of High Risk Drugs in Hospital. *Chinese pharmaceutical affairs* 2017;31(09):1067-1071. (in Chinese)

[19] Heather H, Kate H, Simon M, Daniel A-S, Abigail K, Michele C. Managing uncertainty in medicine quality in Ghana: The cognitive and affective basis of trust in a high-risk, low-regulation context. *Social Science & Medicine* 2019;234.

[20] Jianfang S and Xiaowei G, Construction and effect evaluation of hospital drug inventory management system. Cardiovascular Disease *Electronic Journal of Integrated Traditional Chinese and Western Medicine* 2019;7(14):195. (in Chinese)

[21] Yingrong L, Problems in Drug Storage and Preventive Suggestions. *Clinical Medical Research and Practice* 2016;1(18):186-187.

[22] Baldwin K, Walsh V. Independent double-checks for high-alert medications: essential practice. *Nursing* 2014;44(4):65-67.

[23] High-Alert Medications in Acute Care Settings | Institute For Safe Medication Practices. Vol 20212021.

[24] Alshakka M, Badulla W, Ibrahim MIM. Knowledge, Attitudes and Practices Survey of Medication Safety among Community Pharmacists in Aden-Yemen. *JOURNAL OF PHARMACEUTICAL RESEARCH INTERNATIONAL* 2021;33(23A):13-27.

[25] Mansour M, James V, Edgley A. Investigating the safety of medication administration in adult critical care settings. *NURSING IN CRITICAL CARE* 2012;17(4):189-197.

[26] Graham S, Clopp MP, Kostek NE, Crawford B. Implementation of a high-alert medication program. *Perm J* 2008;12(2):15-22.

[27] Sessions LC, Nemeth LS, Catchpole K, Kelechi TJ. Nurses' perceptions of high-alert medication administration safety: A qualitative descriptive study. *JOURNAL OF ADVANCED NURSING* 2019;75(12):3654-3667.

Graphical abstract:

It is found that almost 21% of the 336 pharmacists from South China, North China and Central China have low-level knowledge of high-alert medication. Based on the investigation results, this paper analyzes the factors influencing the knowledge level of high-alert medication, and finds out

DOI: 10.55415/deep-2022-0026.v1

several effective methods to ameliorate the knowledge level of pharmacists on high-alert medication, so as to improve the use of high-alert drugs and further safeguard the drug safety of patients.