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The link between patient safety competence and adverse event among master of nursing students: a cross-sectional mixed-methods study

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Abstract

Background Patient safety (PS) is a core competency for registered nurses. However, there is a gap between the PS competence of nursing students and their clinical experience in PS. This study explored the effect of PS competence levels on the occurrence of adverse events (AEs) among nursing master's students in China.

Methods A sequential mixed methods design was used, with a purposive sample across seven colleges. A total of 327 graduate nursing students, aged 22 to 38, participated in the survey, and 15 participated in qualitative interviews. The Health Professional Education in Patient Safety Survey (H-PEPSS) assessed the students' competence levels in PS. The respondents also reported any AEs that they had been involved in over the past year.

Results A total of 78 AEs occurred in the past year, with 17.7% of the participants involved 1 to 3 AEs. The most common AEs were medication administration errors (30.77%) and improper use of medical equipment/supplies (28.20%). Students acquired more competencies from the clinical setting than from the classroom setting. Three competencies learned from classroom settings were associated with clinical AEs: low clinical safety skills [OR=0.61], inappropriate identify, response to and disclosing AE and close calls [OR=0.454], and low confidence in working in teams with other health professionals [OR=2.168]. Qualitative data analysis revealed five themes: recognizing AEs, reducing harm by addressing immediate risks to patients and others involved, promoting safe medication and clinical practice, managing members' authority and team dynamics, and dealing with inter-professional conflict.

Conclusions The quantitative and qualitative data align, supporting the enhancement of students' PS competence.

Keywords Patient safety, Adverse events, Competence, H-PEPSS, Master nursing students

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Background

The Institute of Medicine defined patient safety (PS) as “the prevention of harm to patients.” Competence in PS is essential for all healthcare providers, as technologies and patients’ conditions rapidly evolve [1]. Evidence has shown that hospitals in low- and middle-income countries account for 134 million adverse events (AEs) and 2.6 million deaths annually, with human factors being the leading cause of most AEs [2]. Since the releases of the ‘To Err is Human’ report [3], there has been an improvement in the quality of care and PS. However, progress in implementing quality improvement and PS education in schools is still slow or inconsistent with clinical practice [4]. If healthcare-related students are not adequately prepared in PS skills during school, it may increase the cost of clinical training. World Health Organization (WHO) emphasized that PS principles should be essential to educational and clinical training for all healthcare professionals. According to a recent study, educating nursing students on PS can partially improve their long-term competencies in the PS area [5]. Chinese nurses are vital in maintaining PS, like their counterparts worldwide. While they are not authorized to make diagnoses or write prescriptions, they are essential in coordinating PS activities. Especially they play a crucial role in preventing near misses and errors in prescribing and administering medication, minimizing instances of missed nursing care, and enhancing the safety of surgical procedures [6].

A previous study advocated that advanced nurses with master’s level education might lead to better professional teamwork and patient outcomes [7]. According to the Essentials of Baccalaureate Education for Professional Nursing Practice, nurses who have completed a master’s degree program must possess the necessary skills to provide high-quality care and to ensure PS [8]. They should also have sufficient knowledge to identify potential safety hazards and the confidence to safeguard patients from harm or injury [9–11]. In China, all nursing master’s programs are three years long. Moreover, these programs implement a standardized curriculum [12]. Chinese nursing educators focus on enhancing students’ clinical competencies. However, there is a lack of explicit attention given to the area of PS [13]. Most nursing schools concentrate only on specific issues, such as safe medication or fall prevention. They neglect the broader concepts of PS principles [14]. This situation has led to reconsidering the primary purpose of advanced nursing education [15]. Recently, there has been an increasing emphasis on the required knowledge, skills, attitudes, and behaviors related to PS. However, studies have shown that PS training is not uniform in nursing education [16]. Therefore, merely teaching nursing students the WHO Surgical Safety Checklist would not be enough to reduce AEs. It is important to develop PS competencies among nursing

students, particularly in the master’s program. Therefore, urgent action is required to promote personal and multi-professional attributes [1].

Theoretically, possessing knowledge and skills in PS should help reduce errors. However, studies have shown that a significant number of nursing interns (ranging from 17 to 53.2%) [17] and 40% of newly recruited nurses [18] in China have experienced errors. The previous educational system in China did not adequately prepare nursing students with the necessary expert knowledge base, complex decision-making skills, and clinical competencies required for PS practice. It remains unclear whether errors in PS are a result from shortcomings in classroom learning or clinical practice, due to the lack of a structured PS curriculum and limited research in this area [19]. Previous studies found that students can develop PS competence through both classroom instruction and clinical practice. However, the Health Professional Education in PS Survey (H-PEPSS) identified weaknesses in current nursing curricula related to PS [19–21]. The New Era report has proposed guidelines for strengthening academic partnerships and integrating them into healthcare systems [8, 22]. It is essential to connect classrooms and clinical settings to better coordinate education and healthcare systems, enhance student learning, and ensure PS [14].

The importance of providing master’s students with improved preparation in PS competencies has been recognized, as they are expected to take on a leading role in ensuring the safety of the healthcare system. The current study used a mixed-methods design to incorporate PS competencies from the Quality and Safety Education for Nurses (QSEN) project into teaching practice at the master’s level. This study aimed to (1) describe and compare the confidence level of PS knowledge and competence levels acquired in both classrooms and clinical settings; (2) describe the breadth of addressing PS issues in health professional education and the comfortable level of talking about PS issues; (3) explore the impact of PS competence on errors.

Methods

The study utilized a mixed-methods approach, an explanatory sequential design [23]. The first phase of the study used a quantitative (QUAN) approach to confirm the association between PS competence and AEs. In the second phase, a qualitative (QUAL) approach was used, involving semi-structured interviews with a small group of students to gain a deeper understanding of the phenomenon being studied and further validate the QUAN data findings. The Institutional Review Board approved the study at the research sites.

Study participants

The first phase of the study involved a web-based survey conducted in seven colleges located in Central and Eastern China from September 2021 to January 2022. The survey targeted students who were currently enrolled in a three-year master's nursing program and had been working in a clinical setting for over a month. We invited all 363 master nursing students to participate in the study, and 327 of them responded and completed the survey. All participants signed an electronic informed consent before taking part in the study. In the second phase, we based on the mean of the confidence level of PS competence, we identified potential qualitative interviewees from both low- and high-scored groups. Data collection and content analysis were conducted simultaneously, and interviews stopped when data saturation was reached.

Measurements

The study gathered QUAN data from participants using standardized questionnaires, which including their demographics (age, gender, and academic year), PS confidence levels, and AEs experienced within the past year. The Health Professional Education in Patient Safety Survey (H-PEPSS) [24], a psychometric sound instrument, was used to measure the participants' confidence level of PS competence. The H-PEPSS is a 31-item, 5-point Likert-type scale and includes the following three Sect. [20]:

1) *Learning about specific PS content areas (20-item, seven dimensions) in both classroom and clinical settings*, which includes six dimensions of PS competence (16-item) and one dimension of clinical skills (4-item). The 16-item PS competence emphasized six areas: contribute to a culture of patient safety (3 items), work in teams for PS (3 items); communicate effectively for PS (3 items), manage safety risks (3 items), optimize human and

environmental factors (2 items), and recognize, respond to and disclose AEs and close calls (2 items).

2) *How broader PS issues are addressed in health professional education (7-item)*.

3) *Comfort speaking up about PS (4-item)*.

Responses are rated on a 5-point Likert-type scale from 1 (strongly disagree) to 5 (strongly agree), with a 'don't know' option (score=0). Higher scores indicated greater perceived PS competence. The percentages of respondents who agreed (agree/strongly agree, >3.5) for each item were compared between classroom and clinical learning settings [20].

The Chinese version of H-PEPSS was not available. Therefore, the third author (QW) sought permission from the tool's original developers to translate it into Chinese. A team was established to do the translation using translation theory [25] and the recommended cross-cultural research procedures [26, 27] to forward- and backward-translate the H-PEPSS. This was done to ensure that the original and target language had the same meaning and content equivalence. In a previous study, Cronbach's alphas for the seven dimensions in the content areas ranged from 0.81 to 0.85 [28]. In the current study, the range was from 0.85 to 0.91.

The participants reported AEs according to the criteria established by the Chinese Hospital Association [29]. These AEs can be classified into four categories: (a) severe AE, which includes unexpected death or permanent loss of physical function not resulting from the natural disease process; (b) moderate AE, which refers to dysfunction caused by medical treatments rather than the disease itself; (c) mild AE, which refers to errors occurred do not cause harm the patient or can be fully recovered without any treatment; and (d) near miss, which refers to errors that were detected in time and did not result in harm to the patient. Each nursing student filled out the AEs and safety risks that they have personally experienced or witnessed, either identified or anonymously.

For the qualitative study, an inquiry was conducted through individual interviews. The inquiry focused on three main aspects: personal experiences with AEs, the impact of PS competence on AEs occurrence, and the factors that influence perceived PS competence. Table 1 details the sub-questions that were used to guide the study.

Data collection and analysis

The Student Union of the School of Nursing sent recruitment emails through WeChat, a typical social media in China. Potential participants were informed that whether they took part in the study or not, they wouldn't lose any benefits as students at the school, and completing the questionnaire was completely voluntary. Informed consent and a link to the questionnaire were sent from

Table 1 Nursing students' semi-structured interview: topics and sub-questions

Topics	Sub-questions
Last experiences with personal AEs	Describe the event? What is the impact of AEs on yourself, physically and mentally?
Impact of PS competence on occurring AEs	Could you handle the situation and your actions? What was the reaction of your team? What is the impact of PS competence on your AE's experience and patient care?
Aspects that influence perceived PS competence	What are the circumstances that you perceive PS competence in the classroom and clinical setting? How do these circumstances occur? Does certain someone (teacher, classmate, colleague...) has a particular role in such a situation? In your opinion what is acceptable PS training and what is the lacking? How do you cope situations when your perceive the lacking of PS competence?

a secure online platform called Wenjuanxing, a popular online survey platform in China. Demographic information and questionnaire data were stored separately to ensure anonymity and confidentiality. All interviews were audio-recorded for further data analysis.

Quantitative data were analyzed using the SPSS 24.0 version. Categorical data were dummy-coded, and all data were evaluated to ensure they met statistical assumptions. The participants were divided into two groups based on self-reported AEs: those who experienced an event and those who did not. Descriptive statistics were used to describe sample characteristics and significant variables. The chi-square test and t-test were used to explore the differences between those who experienced AEs and those who did not. The correlation test examined the associations between the outcome variable (self-reported AEs) and independent variables. Finally, the binary logistic regression model was used to analyze the variables that were found to be significantly associated with the outcome variable.

Qualitative data were analyzed using descriptive thematic analysis. The data collection and analysis were conducted simultaneously. The codebook was developed iteratively, and the final codes were confirmed before completing the final analysis. The entire research team reflected on the results and discussed the data rearrangement under different themes using NVivo 10 software. Each quote was individually reported in the results Sect. [30].

Table 2 Demographic characteristics of master nursing students (N = 327)

Variable	Mean±SD/ N (%)	With AEs*	Without AEs	p
		(n = 58) Mean±SD/ n (%)	(n = 269) Mean±SD/ n (%)	
Age (years)	24.97±3.41	23.48±2.30	25.29±3.52	0.000*
Gender	274 (83.8)	48 (82.8)	226 (84.0)	0.814**
Female	53 (16.2)	10 (17.2)	43 (16.0)	
Male				
Academic year	113 (34.6)	36 (62.1)	77 (28.6)	0.000***
1st	116 (35.5)	18 (31.0)	98 (36.4)	
2nd	98 (30.0)	4 (6.9)	94 (34.9)	
3rd				
Schools				0.000***
1	32 (9.8)	0 (0)	32 (11.9)	
2	48 (14.7)	2 (3.4)	46 (17.1)	
3	58 (17.7)	5 (8.6)	53 (19.7)	
4	47 (14.4)	8 (13.8)	39 (14.5)	
5	46 (14.1)	10 (17.2)	36 (13.4)	
6	68 (20.8)	28 (48.3)	40 (14.9)	
7	28 (8.6)	5 (8.6)	23 (8.6)	

The t-test (*), Chi-square test (**), and Fisher's exact test (***) were used with the significance level (p) of <0.05

Results

Quantitative study: model confirmation

Sample characteristics

Three hundred sixty-three students enrolled in nursing master's programs from 7 schools were recruited for the study. Out of these, 327 students (90.1%) participated in the online survey (Table 2). The participants' ages ranged from 22 to 38 years, with a mean of 24.97 (SD=3.41). Most participants were female (83.8%), and about 17.7% reported experiencing 1 to 3 AEs in the past year. A total of 78 AEs were reported, including inappropriate medication administration errors (n=24, 30.77%), issues with medical equipment and supplies (n=22, 28.20%), fall/drop from bed (n=10, 12.82%), intravenous infiltration (n=8, 10.26%), pressure injuries (n=5, 6.41%), scalds (n=4, 5.13%), tube detachments (n=4, 5.13%), and aspiration (n=1, 1.28%).

Self-reported confidence in PS competence

The confidence levels of PS knowledge acquired in classroom and clinical settings are detailed in Table 3. Students reported the highest levels of confidence in *understanding human & environmental factors* (89.6% in the classroom and 87.8% in clinical settings), followed by *communicating effectively* (88.4% in the classroom and 86.5% in clinical settings). The lowest confidence levels were observed in *recognizing, responding to, and disclosing AEs and close calls* (68.8% in the classroom and 71.6% in clinical settings). Notably, the classroom learning of *clinical safety skills, working in teams with other health professionals, and managing safety risks* were statistically significantly lower than in clinical settings.

Regarding the broader PS issues included in the current education (Table 4), most students (78.6%) agreed that timely reporting of AEs can help in reducing the recurrence of adverse PS events. Additionally, over half of the students (63%) also agreed that their preceptors handled PS issues similarly. In terms of speaking about PS issues (Table 4), most students (78%) expressed that they were afraid of facing disciplinary action if they made a serious mistake. Furthermore, 61.2% of students reported difficulties questioning those with higher authority, which could be attributed to the Chinese culture of respect for seniors.

Factors affecting nursing student's AEs

Tables 2 and 3 present a bivariate analysis with six variables. The binary logistic regression model analysis (Table 5) included three variables in the final model and an acceptable Nagelkerke R-squared value of 0.32. The likelihood of AEs occurring depends on the lower ability to practice clinical safety skills (odds ratio [OR]=0.61; 95% confidence interval [CI], 0.374~0.997) and to identify, respond to, and disclose AE and close calls

Table 3 Patient safety competence in different learning settings and different groups (N=327)

Variable		Mean±SD	p*	With AEs (n=58)	Without AEs (n=269)	p*	Agreement N (%)	p**
Clinical safety skills	Class	4.24±0.84	0.020	4.02±0.94	4.29±0.71	0.025	269 (82.3)	0.056
	Clinical	4.34±0.68		4.29±0.98	4.35±0.59		0.524	
Work in teams with other Health professionals	Class	4.09±0.78	0.016	4.01±0.95	4.15±0.71	0.046	238 (72.8)	0.269
	Clinical	4.18±0.68		4.17±0.95	4.18±0.60		0.914	
Communicating effectively	Class	4.40±0.71	0.109	4.38±0.97	4.41±0.64	0.763	289 (88.4)	0.440
	Clinical	4.36±0.67		4.38±0.99	4.35±0.58		0.787	
Managing safety risks	Class	4.12±0.74	0.006	3.99±0.96	4.14±0.69	0.165	247 (75.5)	0.205
	Clinical	4.22±0.71		4.19±1.01	4.22±0.63		0.756	
Understanding human & environmental factors	Class	4.34±0.65	0.602	4.22±0.97	4.37±0.56	0.108	293 (89.6)	0.430
	Clinical	4.33±0.66		4.32±1.00	4.33±0.56		0.935	
Recognized, respond to and disclose adverse events and close calls	Class	4.11±0.66	0.443	3.94±0.90	4.15±0.59	0.033	225(68.8)	0.466
	Clinical	4.13±0.65		4.03±0.97	4.15±0.56		0.213	
Culture of safety	Class	4.26±0.65	0.171	4.14±0.97	4.28±0.56	0.120	268 (82.0)	0.719
	Clinical	4.22±0.66		4.12±0.99	4.25±0.57		0.189	

The t-test (*) and Chi-square test (**) were used with the significance level (p) of <0.05

Table 4 Broader aspects of patient safety and comfort in speaking up about patient safety (N=327)

Variable	Mean±SD	Agreement N (%)
<i>How broader PS issues are addressed in health professional education</i>		
1. As a student, my scope of practice was very clear to me	3.73±0.68	225 (68.8)
2. There is consistency in how patient safety issues were dealt with by different preceptors in the clinical setting	3.61±0.74	206 (63.0)
3. I had sufficient opportunity to learn and interact with members of interdisciplinary teams	3.61±0.75	215 (65.7)
4. I gained a solid understanding that reporting adverse events and close calls can lead to change and can reduce reoccurrence of events	3.86±0.65	257 (78.6)
5. Patient safety was well integrated into the overall program	3.76±0.62	240 (73.4)
6. Clinical aspects of patient safety (e.g. hand hygiene, transferring patients, medication safety) were well covered in our program	3.84±0.64	255 (78.0)
7. "System" aspects of patient safety were well covered in our program	3.79±0.66	250 (76.5)
<i>Comfort speaking up about patient safety</i>		
1. If I see someone engaging in unsafe care practice in the clinical setting, I feel I can approach them	3.83±0.70	247 (75.5)
2. If I make a serious error I worry that I will face disciplinary action	3.90±0.73	255 (78.0)
3. It is difficult to question the decisions or actions of those with more authority	3.56±0.82	200 (61.2)
4. In clinical settings, discussion around adverse events focuses mainly on system-related issues, rather than focusing on the individual(s) most responsible for the event	3.79±0.73	240 (73.4)

(OR=0.454; 95% CI, 0.228~0.903). Additionally, lower perceived confidence in working with other health professionals in teams (OR=2.168; 95% CI, 1.077~4.366) increased the likelihood of AEs happening.

Qualitative study: semi-structured interviews

Fifteen female interviewees, who were first to third-year students, participated in the study. Their age ranged between 22 and 28 years (Mean=24.33, SD=1.63). Only 26.67% of them had clinical working experience after completing their undergraduate degree, which ranged from 6 to 24 months before they started their graduate study.

During the QUAL study, 34,644 words were transcribed from interviewees' contents. Only the transcribed texts relevant to the study purpose were extracted and used as the "reference point" or analysis unit. The "tree nodes" were established by analyzing the association among "free nodes." The interview content was divided into 110 analysis units, all related to PS competence. These units formed five themes, which were (1) recognizing AEs, (2) reducing harm by addressing immediate risks to patients and others involved, (3) promoting safe medication and clinical practice, (4) managing team dynamics and authority differences, and (5) dealing with inter-professional conflict.

Theme 1 Recognizing AEs.

All participants expressed they lacked knowledge about AEs, near misses, and how hospitals deal with the events, as the school did not provide the related information.

"Neither undergraduate nor the graduate students have systematically learned relevant knowledge or participated in relevant training during the school stage (Interviewee 3)."

Table 5 Association between patient safety competence and occurring AEs (N=327)

Model term	Estimate	SE	Wald	P	OR	95% CI
Clinical safety skills (class)	-0.494	0.250	3.892	0.049	0.610	0.374–0.997
Work in teams with other health professionals (class)	-0.774	0.357	4.695	0.030	2.168	1.077–4.366
Recognized, respond to and disclose adverse events and close calls (class)	-0.789	0.351	5.060	0.024	0.454	0.228–0.903
Age	-0.110	0.078	2.001	0.157	0.896	0.769–1.043
Academic year			3.583	0.167		
Academic 1st year = 1	1.326	0.701	3.580	0.058	3.768	0.953–14.888
Academic 2nd year = 2	0.996	0.636	2.450	0.118	2.708	0.778–9.425
Schools			10.999	0.088		
School = 1	-20.036	6747.643	0.000	0.998	0.000	0.000
School = 2	-1.002	0.953	1.106	0.293	0.367	0.057–2.377
School = 3	-0.723	0.744	0.943	0.331	0.485	0.113–2.087
School = 4	-0.070	0.728	0.009	0.924	0.933	0.224–3.882
School = 5	-0.156	0.696	0.050	0.823	0.856	0.219–3.348
School = 6	0.821	0.621	1.743	0.187	2.272	0.672–7.679

Only 26.67% of the interviewees accurately define near misses. After defining near misses, 66.67% said it should be taught in the classroom. However, they also felt that collecting near misses is challenging due to the hospital's lack of a concise principle.

“The hospital's requirements for reporting near misses are vague, and no dedicated reporting system exists. There are barriers in the educational system due to the lack of cases. (Interviewee13).”

Theme 2 Reducing harm by addressing immediate risks to patients and others involved.

All interviewees stated the need to report AEs to the nurse manager responsible for handling them. However, classroom and clinical settings lack instruction on how to deal with the incident and cope with AEs.

“ I hung up a wrong infusion bag once, and the patient's wife found it. Fortunately, the medicine ingredients were the same and did not cause any damage to the patient. The nurse manager helped me explain the situation to the patient and his wife and taught me a lesson. I felt very sad(Interviewee 2).”

“The faculty member told us not to give the wrong medicine, but besides checking, I didn't know what else to do, and I was very worried that I would make a mistake (Interviewee 5).”

All interviewees suggested that classroom training should be conducted on patient safety and risk management.

“As a graduate student, I have a nurse's license, but I'm not a staff nurse in the hospital. The nursing faculty members worried we might make mistakes, prohibiting us from some practices. I understand this, but I will work in the clinic eventually. Can the school provide training on preventing AEs before our clinical practicum? (Interviewee 9).”

“I think we should collect some AE cases and do case studies in the classroom (Interviewee 1).”

“Books related to preventing AEs are hard to find in school libraries (Interviewee 11).”

“I have been working in clinical for two years. Nurses may make mistakes in their daily work. I want to improve my ability to prevent the occurrence of AEs, so I am applying for postgraduate study. However, there is a lack of teaching materials and training in the nursing field to prevent AEs (Interviewee 15).”

Theme 3 Promoting safe medication and clinical practice.

All the interviewed graduate students indicated that the requirements for hand hygiene and infection control have increased in schools and hospitals since the outbreak of COVID-19. However, 66.67% of the interviewees expressed their desire to improve their knowledge of safe medication practices and clinical practice in the classroom, especially for using specialized medications and medical equipment. Additionally, they suggested that the HIS system should introduce extensive data analysis related to PS, and more online learning resources and tools should be added to support their education.

"I learned about medication safety in my undergraduate program. My teacher emphasized the "three checks and eight rights." I did not learn in-depth in the postgraduate program. Currently, the nursing field is exploring the issue of improving PS based on the big data from the HIS system. Can the faculty members focus on this aspect in classroom teaching?" (interviewee6).

In China, there are two methods to prevent medication errors: the "three checks" and the "eight rights." According to the Chinese nursing practice standard, the "three checks" methods involve checking medication before, during, and after preparation. The "eight rights" method ensures that the right patient, correct bed number, proper medication, right dose, right route, right concentration, right time, drugs, and disposable medical supplies are used within their expiry date.

"My specialty is adult intensive care, but I went straight to graduate school after my undergraduate degree and had no experience working in the specialty area. There are many devices in the ICU, such as ventilators, infusion pumps, monitors, etc., and I just tagged along with the clinical faculty to learn how to use them, but as soon as I heard the alarm, I was scared." (Interviewee 4).

"My major is pediatric nursing. When I was rotating in the NICU and PICU, I was especially worried that the doctor prescribed the wrong orders. Some doctors would miscalculate the drug dosage. Can the school provide online learning resources and tools to facilitate our access to and knowledge of drug dosage?" (Interviewee 12).

Theme 4 Managing team dynamics and authority differences.

How team dynamics and authority/power are taught in classrooms differs significantly from the clinical situation. The nurse manager's leadership style greatly influences how students handle errors, including near misses.

"In my opinion, although the teachers and the nurse managers advocated active reporting AEs, it is difficult to do it in the clinic, and the attitude of the nurse manager determines everything (Interviewee 11)."

"In the hospital where I worked before, whenever there was an error, the nurse manager usually criticized, instead of seeking the causes with the nurse,

which was different from what the teacher said in the classroom (Interviewee 14)."

"It's very difficult to be anonymous and confidential if there is a mistake in the department. If there is no damage to the patient, I won't report it because it will affect my grades when I finish my clinical rotation. If AEs were reported to the nursing department, I can't have a job offer in this hospital (Interviewee 10)."

Many students find it challenging to handle excessive work when working in teams. Moreover, they worry about any occurring AEs in teamwork.

"Sometimes, the stress from studying and my workload is so overwhelming that I must express my feelings and lose my energy simultaneously. I worry about insufficient sleep and causing AEs (Interviewee 4)."

"In the classroom, the teacher only told us that collaborating with colleagues and other healthcare workers was supportive and helpful to prevent AEs, but I don't know how to do it. Sometimes the more you do it, the more mistakes you get (Interviewee 7)."

"In the clinical setting, the excessive workload is unacceptable, and teamwork is compromised (interviewee 12)."

Theme 5 Dealing with inter-professional conflict.

Interviewees expressed that interdisciplinary meetings were essential to ensure nurses have access to accurate patient information and care requirements.

"Competent physicians proved clear medical orders and communication (interviewee 10)."

Accurate communication was essential within the team and at the patient safety management level, except for AEs that occurred.

"When an AE occurred, it's all the nurse's fault. I don't know how to express my opinions or reflections to others. However, when I consider patient safety and quality of care, I report AEs (interviewee 6)."

"The nurse administrators do not always listen and respond to nurses' concerns about conflict with other healthcare workers (interviewee 10)."

"Calls for help must be answered; nurses never com-

plain, but when nurses call for help, the hospital management level should pay attention (interviewee 15)."

Discussion

This study used mixed methods to explore the PS of nursing master's students in PS and its impact on errors. The key points of the study findings are discussed below.

Knowing environmental risk factors can assist students in preventing errors

In the current study, participants reported feeling most confident in their *understanding of human & environmental factors* in both classroom and clinical settings. This contrasts with previous surveys of undergraduates in Saudia Arabia and Canada, which showed that the students were more confident in *clinical safety skills* and *effective communication* in PS [31, 32]. These variations may be attributed to different educational systems. It is important to note that AEs can be caused by human errors, systematic errors, or both. Some AEs can be prevented, while others cannot. Therefore, it is important to identify the factors that cause preventable and non-preventable errors, and then customize education and training programs accordingly.

Students reported having the least confidence in *recognizing, responding to, and disclosing AEs and close calls* in both classroom and clinical settings. This is similar to a previous study conducted among undergraduate students in China [21], and it significantly affects the prevention of AEs. The QUAL data confirmed the importance of standardized training in recognizing and dealing with near misses and AEs. Especially after the COVID-19 pandemic, PS became even more important. It is recommended that PS training be integrated into the nursing education curriculum, starting from undergraduate studies and continuing through postgraduate training and clinical practice. Moreover, it should be a lifelong learning process for nurses.

Non-blaming culture should be improved through a combination of classroom and clinical learning

When discussing PS, students often hesitate to speak out as they fear being punished if they make a serious mistake. In China, hospitals lack a safety culture that encourages non-punitive responses to errors and provides minimal organizational support at all levels. This underscores the significance of mutual respect and the implementation of a better structure for teamwork to strengthen PS practice [33].

Adopting a dual approach involves identifying issues and taking practical corrective actions, which is essential. Nursing educators can play an important role in this

process by creating a clinical environment that encourages open communication and collaborative relationships with nursing managers. Such an environment will help nursing students feel comfortable reporting errors without fear of punishment or negative consequences. Many nursing students said that striving to meet the expectations of both the classroom and the clinical setting has led to feelings of inadequacy and frustration. These emotions can affect not only the individual nursing student but also the entire team. Quality and PS are ensured when students can quickly and accurately assess patients' conditions and clinical symptoms, leading to a positive work and learning environment. Teaching mindfulness and active listening to students [34] can improve patient-centered care and teamwork, ultimately leading to better outcomes [35]. To achieve a healthy nursing workforce and excellence in quality and safety, it is important to establish a supportive and empowering work and learning environment. School and clinical administrators should collaborate and provide resources for students to enhance their awareness and competence in PS.

Inter-professional education (IPE) should begin in the classroom

The findings of this study suggest that if healthcare professionals cannot work together effectively, there is a greater chance of AEs occurring. In China, health-related disciplines do not often interact in a classroom before clinical practice. Nonetheless, studies have shown that effective collaboration among healthcare disciplines, especially nurses, is essential for enhancing the quality of care and PS [9]. The bridge between healthcare providers is a significant factor in reducing serious patient harm [36]. Participants in the current study described the importance of accurate information and necessary care requirements for patients. Achieving this requires managing high levels of PS and maintaining a realistic workload while building strong interdisciplinary relationships with physicians and creating positive working conditions. The curriculum should incorporate diverse teaching methods such as simulation, team-based learning, and problem-based case study learning to enhance teamwork skills and collaboration across healthcare disciplines [37]. This is a way to promote patient safety education, which helps prevent diagnostic, therapeutic, and administrative errors. It is important to integrate patient safety awareness and training into nurse education programs and carry it through to clinical practice.

Decision-making learning can facilitate the transition from classroom to clinical practice

The confidence level of students in *managing safety risks* was found to be significantly lower in the classroom than in clinical settings (Table 3). In China, hospitals oversee

nursing safety for students [17], which allows them to gain a better understanding of safety risks [38]. In China, master's students often work as teaching assistants, giving them the opportunity to observe preceptors' decision-making. The study participants stated that their clinical preceptors didn't handle PS issues well. They also observed an increase in complex care demands due to the COVID-19 pandemic. These findings are consistent with those of a previous study [39]. Several factors may contribute to the perception of AEs. These include recognizing AEs, minimizing harm, and following safe medication practices. Collaborative efforts in PS on a global scale encourage and motivate students to understand healthcare disparities and assess their practice as they advance in their careers. This empowerment helps individuals become champions of PS [10]. The curriculum should focus on enhancing the decision-making skills of PS professionals through collaboration with international safety practitioners. A study has revealed no clear distinction between the roles and responsibilities of PS officers or risk managers in healthcare during a pandemic compared to their regular responsibilities [40]. Therefore, further study is necessary, particularly as master's program graduates will emerge as future clinical leaders who must be able to identify and address AEs.

Limitations

This study is the first to use a mixed method to explore the impact of PS competence on AEs among master nursing students. The findings of this study are essential in understanding the current state of PS curriculum development and provide valuable information for nursing educators to improve master's education programs in both classroom and clinical settings. However, the study has some limitations. Firstly, construct validity (e.g., confirmatory factor analysis) might be needed for the H-PEPSS to ensure that the construct remains unchanged in the Chinese version of H-PEPSS. Secondly, selection bias is a standard limitation in cross-sectional studies. Therefore, future longitudinal studies are needed. Thirdly, because the participants provided self-reported data through an online survey, there may be a social desirability bias where students overestimate or underestimate their competencies in PS due to differences in knowledge and expectations. Fourthly, there may be recall bias when reporting AEs over the past year, which could be resolved by prospective studies, and we intend to report in due course. Finally, although the study participants' extensive clinical practice period (3–18 months), no detailed data were available for subgroup analysis.

Conclusions

The nursing curriculum in China has recently begun incorporating PS education to improve the knowledge and skills of nursing students. This study involved QUAN models and QUAL interviews to explore the impact of different factors on AEs, including risk and protective factors. The study highlights enhancing risk management knowledge to ensure continuous quality improvement. It also provides valuable interdisciplinary learning experiences for master's degree students in China and elsewhere. Nurse educators should equip students with essential skills, knowledge, and confidence to minimize AEs in healthcare settings. Additionally, they can encourage non-punitive responses to clinical errors, empowering students to speak up about AEs.

Abbreviations

PS	Patient Safety
AE	Adverse Event
IPE	Inter-professional education
H-PEPSS	Health Professional Education in PS Survey
SPSS	Statistical Package for Social Sciences
OR	Odds ratio
CI	Confidence interval

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Author contributions

X.Z. conceptualized and designed the project, performed data analysis and interpretation, drafted and finalized the manuscript. F.W. assisted in data collection and data management. Q.W. established a team to translate the H-PEPSS into a Chinese version and data collection. H.L. conceptualized and designed the project. S.Y.L. monitored the integrity of data presentation and manuscript writing. All the authors reviewed the manuscript.

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Data availability

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics statement and consent to participate

The study was conducted under the standard and ethical criteria of the Helsinki Declaration and was approved by the Institutional Review Board of Peking Union Medical College (IRBPUMC10023201902502). Attached to each questionnaire was a cover letter explaining what was expected of the participants who had to sign, indicating their informed consent before they provided answers. In this way, all participants were informed whether they participated in the study, and completing the questionnaire was voluntary. Data were handled in accordance with the right to privacy, ensuring anonymity and confidentiality of the responses. The third author obtained permission via email from the copyright holder to use the questionnaire.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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