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Research article

Types of medication administration errors and comparisons among nursing graduands in Indonesia, Taiwan, and Thailand: A cross-sectional observational study

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ABSTRACT

Background: Despite medication administration safety having been introduced, practiced, and examined in nursing schools for many years, errors are commonly reported among new nurses. Understanding medication errors that nursing graduands might commit is essential for patient safety and fostering collaboration among neighboring countries.
Objectives: To assess and compare types of medication administration errors identified by nursing graduands in Asian countries using a medication errors scenario.
Design: A cross-sectional observational study.
Settings: One university four-year nursing program each in Indonesia, Taiwan, and Thailand.
Participants: A total of 145 baccalaureate nursing graduands in their last semester, including 42 from Indonesia, 35 from Taiwan, and 68 from Thailand.
Methods: The medication errors scenario contained 11 errors. The faculty examiner directly observed and graded the graduands' performance in identifying medication errors using an objective structured medication administration checklist. Descriptive and inferential analyses were used.
Results: Overall, 4.4 ± 1.8 errors on average were identified in the medication errors scenario. The most common types of errors differed among the three countries. More than half of the graduands did not check the patient's wristband ($n = 75$; 51.7%) or discovered the wrong name on it ($n = 88$; 60.7%). Giving medication without an indication ($n = 129$; 89.0%) and giving medication with potential for an allergic reaction ($n = 111$; 76.6%) were the most common errors.
Conclusions: Medication administration errors are common in nursing graduands. Specific types and various frequencies of errors were noted across three countries. Nursing faculties should investigate possible reasons for common types of errors and develop effective education strategies for graduands to prevent errors. Collaboration among neighboring countries is encouraged to improve overall global medication safety.

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1. Introduction

Medication errors are defined as “any preventable event that may cause or lead to inappropriate medication use or patient harm” (National Coordinating Council for Medication Error Reporting and Prevention, 2020). Theoretically, all errors are preventable, but the US Food and Drug Administration (2019) receives more than 100,000 suspected medication error reports each year, indicating a significant need to better understand and stop those errors from occurring. Such errors can occur in the prescribing, transcribing, dispensing, and administering steps. Nurses are primarily involved in administering medications and are the final safety check preventing errors from reaching patients; conversely, they are the last opportunity for errors to occur (Reason, 2005). Because of nurses' critical role in the medication administration process, they are taught principles and skills in nursing programs for safely administering medications. However, medication administration errors are still reported worldwide (Teal et al., 2019; Wondmieneh et al., 2020), indicating that they are a widespread global issue beyond just a national concern.

2. Background

Many factors contribute to medication administration errors. Inexperience and inadequate training are two of the most common human factors reported (Hughes and Blegen, 2008; Wolf et al., 2006; Wondmieneh et al., 2020). In school, nurses learn how to correctly administer medications using the “five rights” principles (Kee et al., 2015; Miller et al., 2016) of giving the *right* medication to the *right* patient in the *right* dose using the *right* route at the *right* time. In addition to satisfying the “five rights,” nurses learn the pharmacology of medications, so they are capable of deciding if a medication can appropriately be administered and if there is any potential for errors (Miller et al., 2016; Teal et al., 2019). Despite adopting these principles to reduce medication administration errors, novice nurses commonly report making medication administration errors (Parry et al., 2015). However, most research on medication administration errors has focused on registered nurses (RNs), while medication administration errors made by nursing students have been less investigated (Kalantarzadeh and Hosseinnejad, 2014; Lin et al., 2014; Teal et al., 2019).

Understanding the types of medication administration errors that commonly occur can provide an opportunity to improve patient safety (Teal et al., 2019). However, underreporting of medication administration errors has also been noted among RNs and nursing students (Kalantarzadeh and Hosseinnejad, 2014; Yung et al., 2016); therefore, analyses of medication error reporting system data might underestimate the frequencies and types of medication administration errors. Simulation might provide an opportunity for nursing educators to observe students' performance in administering medications, particularly in a situation with errors, and for nursing students to improve their technique by hands-on practice in a relatively safe environment (Kuo et al., 2020). In such simulations, students are exposed to situations that reflect actual medication administration processes and errors, and if they make mistakes, no patients will be harmed.

Medication administration errors are a global patient safety issue (World Health Organization, 2016). The Joint Commission International lists medication safety as one of the International Patient Safety Goals across healthcare settings and countries (Joint Commission International, 2020). In an era of globalization and with widespread nurse shortages, nurses have opportunities to work in countries other than their home countries, particularly in the Asian region (Kunaviktikul et al., 2014). An understanding of the frequencies and types of medication errors that might occur while administering medications would help develop tailored strategies to improve medication safety. The purpose of this study was to assess and compare the types of medication administration errors among nursing graduands in Asian countries using a medication errors scenario.

2.1. Theoretical framework

Reason's (1997) Swiss cheese model was used to guide our study's medication errors scenario design. Fig. 1 shows that patient harm occurs when all defense layers fail, errors reach a patient, and adverse outcomes are possible (Reason, 1997). This model (Fig. 1) demonstrates that failure of the final defense is one unsafe action in a chain of many, rather than the only cause; therefore, investigators should eliminate factors that can weaken defenses instead of blaming people (Li and Thimbleby, 2014). Doctors prescribe medications based on a patient's condition, but errors such as wrong medications, medications without an indication, wrong doses, drug–drug interactions, and drug–disease interactions, may occur. If no one identifies such errors in advance, those errors pass to the next level: the pharmacist. In addition to the defensive layer provided by professionals, clinical guidelines and informatics technology are also effective strategies to prevent errors. Some errors pass onward to the delivery personnel on the patient ward if any defense layer fails. Medication errors might consist of the wrong medication delivered to a patient's medication drawer, look-alike sound-alike medication from the same manufacturer, medication without proper indications in the medication order, students picking the wrong medication without comparing it to the medication order, students giving the wrong dose or giving a medication through the wrong route, etc. The Swiss cheese model illustrates that many system errors and human flaws can occur in the medication process and thus be present in the medication administration stage. A safe mediation process cannot rely on only one defense mechanism, but a well-educated and prepared nursing student can act as a strong final defensive layer for patient safety when administering medications.

3. Methods

3.1. Study design

This was a cross-sectional observational study exploring the types of medication errors committed by nursing graduands using a medication errors simulation scenario in Indonesia, Taiwan, and Thailand. The institutional review boards approved this study at three universities (IRB numbers: KE/FK/1173/EC/2019 [Indonesia], N201610015 [Taiwan], and COA.MURA2019/1244 [Thailand]).

3.2. Settings and participants

We purposefully invited three four-year baccalaureate nursing schools to participate because they had comparable backgrounds, including being among the top nursing schools in their country and having similar academic curricula. In this way, we could ensure that student participants had similar educational backgrounds and clinical training, even though they were from different countries. The 2019 nursing students who were in the last semester before graduation were the potential participants. There were no exclusion criteria.

3.3. Medication errors scenario

Simulations provide students with an opportunity to practice their clinical and reasoning skills through various real-life situations (problems) of medication administration (Kuo et al., 2020; Shin et al., 2015). Based on the Swiss cheese model, we purposefully selected representative administration errors from hospital near misses and incidence reports to develop this medication errors scenario. Specifically, we designed a medication scenario that required students to exercise the “five rights” principles to identify the embedded 11 possible medication errors that could occur in the simulation.

The scenario consisted of a 72-year-old female admitted for a urinary tract infection with a medical history of aphasia (inability to talk), hypertension, and an allergy to non-steroid anti-inflammatory drugs

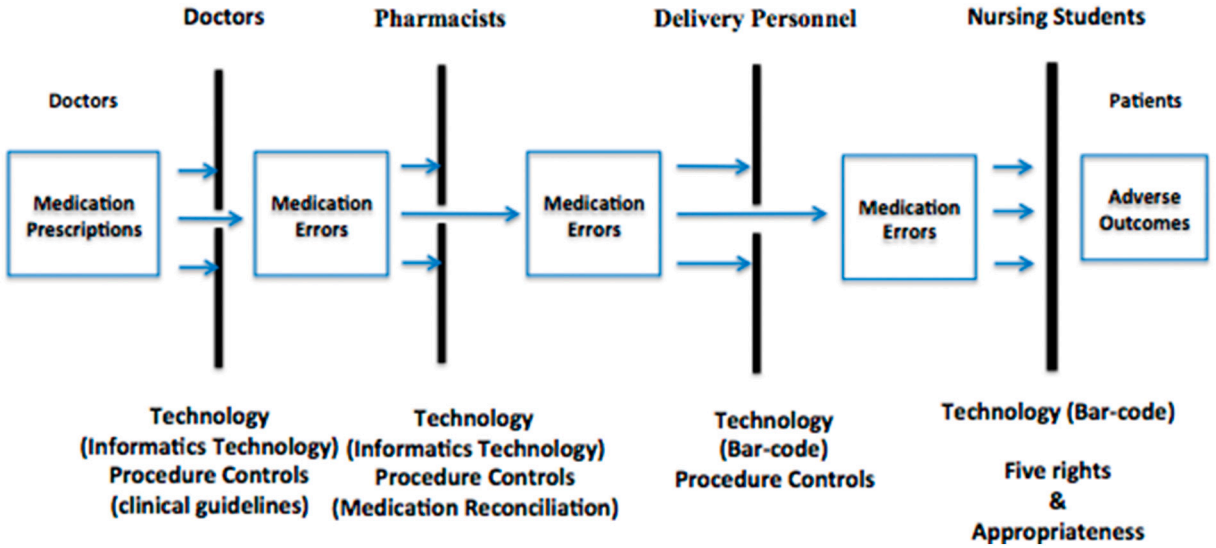

Fig. 1. Adapted from the Swiss cheese model (Reason, 1997). Any professionals, e.g., doctors, pharmacists, delivery personnel, and nurses, could commit errors in the medication administration process and breach defensive layers if there are flaws. Nursing students are responsible for avoiding medication errors by using the "five rights" principles and right indications as the final defensive layer in the medication administration process.

(NSAIDs). The patient's current vital signs were a temperature of 38 °C, a heart rate of 80 bpm, a respiratory rate of 14 times/min, blood pressure of 130/80 mmHg, pulse oxygen saturation (SpO_2) of 99% in room air, and blood sugar of 420 mg/dl. We instructed students that the current time was 09:00, and that they should administer the 09:00 and immediate/STAT medications as per the medication administration sheet (Fig. 2) they had received. Students were expected to administer medications correctly based on the medication administration sheet, except for Cataflam (patient was allergic to NSAIDs), Nexium (medication without an indication), and Sennoside (a laxative taken at bedtime).

3.4. Objective structured medication administration error checklist and reliability development

Fig. 3 shows the objective structured medication administration error checklist for this study, which contained 11 observation points for the student's tested behaviors. The 11-item structured checklist included seven types of medication errors: wrong patient, wrong drug, wrong dose, wrong route, wrong time, medication with a potential known allergy, and medication with no indication. Each item was scored one point for the specific tested behavior by the faculty examiner, with the total score ranging from 0 to 11. The greater the score, the higher the frequency of errors.

The students were instructed to administer the medication and identify any specific errors throughout the medication errors scenario. The faculty examiner observed and graded the students' performance using the checklist mentioned above. For example, the faculty examiner would mark two points for the "wrong patient" error when the students did not check the wristband correctly and did not discover that the wristband had the wrong patient name. Two antibiotics were used to test for the "wrong route" items: whether a student administered these two antibiotics correctly by intravenous push or intravenous drip. In the example of the "wrong dose," the students were tested on identifying whether the medication pack contained 20 mg of Apresoline (antihypertensive medication) instead of the correct dose of Apresoline 10 mg.

Similarly, if a student read the medication label carefully, they should have identified that Cefmetazole (one point for "wrong drug") was in the bag and not Cefazolin ("right drug"). Additionally, three medications were used to test for "no indication," "potentially allergic," and "wrong time," as they should not be administered. Nexium is a

Name: Debby Jones Gender: Female Date of birth: 1947/01/01 ID: Chart number: 0845564														
Medication name	Dosage	Frequency	Route	01	02	03	04	05	06	07	08	09	10	11	12
				13	14	15	16	17	18	19	20	21	22	23	24
Cefazolin 1000mg/amp	1000mg	Q8H	IVP	01								09			
								17							
Gentamicin 80mg/vial/2ml	80mg	Q12H	IVD									09			
												21			
Cataflam 25mg/tab	25mg	QD	PO									09			
Nexium 40mg/vial	40mg	QD	IVD									09			
Sennoside 12mg/tab	12mg	HS	PO												
													22		
Apresoline 10mg/tab	10mg	QD	PO									09			
Insulin Human Regular 1000IU/vial/10ML	10unit	STAT	SC												
\: take medication O: NPO □: HOLD X: Refuse △: examination or surgery =: over time (Using red pen) ∧: absence				E_Nurse				N_Nurse				D_Nurse			

Fig. 2. Medication administration sheet (medication order). A patient with a history of hypertension and type 2 diabetes was admitted to the hospital for a urinary tract infection. The patient was allergic to non-steroid anti-inflammation drugs (NSAIDs) and had a serum blood sugar level of 420 mg/dl.

Type of error	Testing behavior
1. Wrong patient	Did not identify the wristband covered by blanket.
2. Wrong patient	Did not identify the name on the wristband differed from the name on the medication administration sheet.
3. Wrong drug	Did not identify the drug labeled as Cefamatazole being wrong. (The correct one was Cefazolin.)
4. Wrong dose	Did not identify the dosage of Apresoline (20 mg) being wrong. (The correct one was Apresoline 10 mg.)
5. Wrong RI dose	Did not identify the unit of RI (1 ml) being wrong. (The correct one was 10 units RI.)
6. Wrong route-oral	Did not give Apresoline orally. (Apresoline was prescribed to be given orally)
7. Wrong route-IV push	Did not give Cefazolin by an IV push. (Cefazolin was prescribed to be given by an IV push)
8. Wrong route-IV drip	Did not give Gentamycin by an IV drip. (Gentamycin was prescribed to be given by an IV drip)
9. Wrong time	Did not administer Sennoside at bedtime. (Sennoside was prescribed to be given at bedtime.)
10. No indication	Did not identify the Nexium cannot be administered. (There was no indication for Nexium.)
11. Potential allergy	Did not identify the Cataflam cannot to be administered. (The patient was allergic to NSAIDs.)

Fig. 3. Medication administration error checklist. All faculty members were instructed to observe a student's criterion behaviors. If the student performed the specific criterion behaviors, then that meant that the errors occurred, which breached the last defensive layer.
Note: IV, intravenous; NSAID, non-steroidal anti-inflammatory drugs; PO, oral medication; RI, regular insulin.

proton pump inhibitor medication with no clinical indication for this patient; Cataflam is a contraindicated medication (a medication that could elicit an allergic reaction); and Sennoside is a laxative medication (prescribed to be taken at bedtime). If the students gave these three medications, they were rated three points for errors of "no indication," potential "allergic reaction," and "wrong time" (Fig. 3).

All faculty members were instructed about the testing behaviors included in the medication error scenario and the corresponding grading method. Inter-rater reliability across the raters from the three countries was obtained via online meetings. Specifically, a video was presented of a student administering medication in this medication errors scenario. All faculty members rated the students' performance based on the objective structured medication administration error checklist. Concerns or inconsistencies in grading were discussed and clarified until inter-rater agreement reached 100%.

3.5. Statistical analysis

The student characteristics, education regarding medication administration, and types of medication errors among the three countries were analyzed and compared using descriptive statistics, Chi-square analysis, and one-way analysis of variance (ANOVA) with SPSS v. 22.0 software (IBM, Armonk, NY, USA).

4. Results

In 2019, the performances of 145 nursing graduands (42 from Indonesia, 35 from Taiwan, and 68 from Thailand) were observed when administering medications in the medication errors scenario. Table 1 shows the students' backgrounds and their education regarding medication administration. The vast majority of students were female (n = 136, 93.8%), with a mean age of 22.35 ± 1.20 years. Lectures and skill lab practice were the two most common methods for teaching medication administration knowledge and skills across the three countries. Only half of the students (50%) had learned about medication administration via a problem-based approach. None of the Taiwanese students reported problem-based learning as a method used to teach them how to give medications safely and respond to errors.

Table 2 shows the types of medication errors identified by the nursing graduands in three countries. More than half of the students (51.7%) did not check the patient's wristband. Even if students checked the wristband, some did not pay attention to it and failed to identify that the name was for the wrong patient (n = 88, 60.7%). In the three countries, the most common medication error type was the "no indication" error (n = 129, 89.0%), or the "potential allergy" error (n = 111, 76.6%), followed by the "wrong insulin dose" error (n = 63, 43.3%), indicating that those were the areas that need to be further investigated and improved. Overall, the mean medication error for all participants was 4.4 (standard deviation, SD 1.8) in the three countries.

Table 1
Student characteristics and medication safety education training in Indonesia, Taiwan, and Thailand. (N = 145).

	Total n (%), mean ± SD	Indonesia (N = 42) n (%), mean ± SD	Taiwan (N = 35) n (%), mean ± SD	Thailand (N = 68) n (%), mean ± SD
Age (years)	22.35 ± 1.20	23.6 ± 9.92	21.71 ± 0.96	21.84 ± 0.75
Gender				
Female	136 (93.8)	38 (90.5)	32 (91.4)	66 (97.1)
Male	9 (6.2)	4 (9.8)	3 (8.6)	3 (8.6)
Medication administration education				
Lecture				
Yes	135 (93.1)	37 (88.1)	35 (100)	63 (92.6)
No	10 (6.9)	5 (11.9)	0 (0)	5 (7.4)
Skill lab				
Yes	126 (86.9)	28 (66.7)	35 (100)	63 (92.6)
No	19 (13.1)	14 (33.3)	0 (0)	5 (7.4)
Problem-based learning				
Yes	55 (50.0)	20 (47.6)	0 (0)	35 (51.5)
No	55 (50.0)	22 (52.4)	35 (100)	33 (48.5)

Note: SD, standard deviation.

Types of medication errors differed among the three countries (p < 0.05), except for the wrong insulin dosage and giving intravenous medication by a drip. Among the Indonesian students, the most common error was the "no indication" error (90.5%), followed by the "potential allergy" error (59.5%), the "wrong regular insulin (RI) dose" error (40.5%), and the "wrong drug" error (38.1%). For the Taiwanese students, the most common medication error was the "wrong drug" error (85.7%), followed by the "wrong route-intravenous push" error (68.6%), the "no indication" error (68.6%), and the "wrong patient" error (60.0%). For the Thai students, the "no indication" error (98.5%) and the "potential allergy" error (97.1%) were the two most common medication error types, followed by not checking the patient's wristband (73.5%) and not catching the wrong patient name on the wristband (73.5%). The results showed the highest medication errors (6.0 ± 1.9) by the Taiwanese students and the lowest errors (3.4 ± 1.4) by the Indonesian students.

Table 2
Types and differences of medication administration errors among nursing students from Indonesia, Taiwan, and Thailand ($N = 145$).

Error type	Total *n* (%), mean ± SD	Indonesia ($N = 42$) *n* (%), mean ± SD	Taiwan ($N = 35$) *n* (%), mean ± SD	Thailand ($N = 68$) *n* (%), mean ± SD	χ^2/F
Wrong patient					
No wristband check	75 (51.7)	9 (21.4)	16 (45.7)	50 (73.5)	28.89*
Incorrect patient name	88 (60.7)	17 (40.5)	21 (60.0)	50 (73.5)	12.01*
Wrong drug	48 (33.1)	16 (38.1)	30 (85.7)	2 (2.9)	72.16*
Wrong dose					
Tablet dose	32 (22.1)	9 (21.4)	20 (57.1)	3 (4.4)	37.37**
RI unit	63 (43.4)	17 (40.5)	21 (60.0)	25 (36.8)	5.29
Wrong route					
PO	11 (7.6)	0 (0)	10 (28.6)	1 (1.5)	29.06**
IV push	34 (23.4)	3 (7.1)	24 (68.6)	7 (10.3)	52.48**
IV drip	21 (14.5)	6 (14.3)	9 (25.7)	6 (8.8)	5.33
Wrong time	20 (13.8)	3 (7.1)	13 (37.1)	4 (5.9)	21.19*
No indication	129 (89.0)	38 (90.5)	24 (68.6)	67 (98.5)	21.26**
Potential allergy	111 (76.6)	25 (59.5)	20 (57.1)	66 (97.1)	30.06**
Mean (±SD) of all errors	4.4 ± 1.8	3.4 ± 1.4	6.0 ± 1.9	4.1 ± 1.3	28.40**

Note: RI = regular insulin; PO = oral medication; IV = intravenous; SD, standard deviation.
* $p < 0.05$.
** $p < 0.005$.

5. Discussion

This comparative study of three Asian countries provides the first evidence of students' competence in administering medications and types of medication errors using a standardized medication errors scenario in nursing graduands. Through this study, we found that many medication errors could occur, and nursing students might not be capable of identifying them during the administration process. In this medication error simulation, the "wrong patient" error by most of the students indicates that nursing students are at risk of committing medication errors when they practice in the real world (Wolf et al., 2006). The strengths of this multi-country study lie in adopting a medication errors scenario to effectively compare students' performance in different cultural contexts and providing insights to school faculties for developing effective strategies to improve students' medication administration performance. Through international collaboration, we have an opportunity to explore and understand ourselves and other countries' strengths and weaknesses to work together as an alliance for safer practice. A strong safety culture is positively related to nurses' safety performance, which is the most effective intervention for reducing medication errors (Manapragada et al., 2019; Miller et al., 2016).

In the current study, teaching strategies, including lectures and skill labs, were commonly used for all students from the three countries to learn knowledge and practice skills to administer medications. In addition, the problem-based learning of medication administration was offered for the Thai and the Indonesian students during the past four years at school. Past evidence has shown the effectiveness of a problem-based simulation course in lowering medication errors among nursing students (Kuo et al., 2020). Kuo et al. used a 2-h medication simulation course to assess nursing graduands' medication administration performances and facilitate the students to identify their performance weaknesses. Students thus can learn how to overcome their personal deficits, knowledge insufficiencies, and skill slip-ups, leading to safer medication administration in this medication error simulation course. The medication errors scenario could be used to evaluate students' performance in addition to the traditional pencil and paper medication dose calculation test. It could be used as a teaching strategy or active learning method to help students identify their weak areas for booster classes in patient safety and integrate students' knowledge and skills for safe clinical practice.

The five to six "rights" principles of medication administration and medication calculation competency are two main areas taught and assessed in undergraduate nursing programs (Mackie and Bruce, 2016; Miller et al., 2016). Interestingly, despite using the same medication errors scenario, the common error types varied in each country. The nursing faculties in each country use various teaching strategies to improve medication administration safety and thus influence their students' performance in certain error types. As Whitehair et al. (2014) have suggested, skills to detect errors should be practiced to increase the likelihood of detecting and preventing errors. An evaluation of students' performance in administering medications, their characteristics, possible flaws, and reasons for unsafe practices is needed to recognize their strengths and weaknesses before developing effective tailored education strategies. For example, our study found fewer medication errors involving the drug, route, dose, patient, and time by Indonesian and Thai students, but those errors were common among Taiwanese students. Taiwanese nursing faculties should first investigate the reasons for those errors further and develop teaching strategies in accordance with the underlying causes.

In this study, we found that the wrong patient was the most common type of error by nursing students. Based on the Joint Commission's recommendations, a nurse should check a patient's identification each time there is a conversation with a patient (Lyons, 2018). Since the patient in the scenario could not talk, it was vital to check the patient information on the wristband and match the patient with the medication documentation. More than half of the students in our study did not check the patient identification on the wristband, and a higher percentage missed the opportunity to find the wrong patient's name on the wristband, illustrating that the risk of administering drugs to the wrong patient is high among students in Asian countries. Teaching students to use an active confirmation process and a standardized process for patient identification is the first step in error prevention. The Joint Commission states that technology alone cannot ensure patient safety; hence, people involved in the process should be aware and well-trained to carry out reliable procedures in addition to using technology (Lyons, 2018).

The wrong insulin dosage and the wrong route were the other two most common medication error types in this study. Based on Wolf et al.'s (2006) findings, insulin is the most common medication class involved in student errors in the US. Insulin is listed as a high-alert medication because it has high potential to cause patient harm when used in error (Institute for Safe Medication Practice, 2018). In this study, we found that students often chose the wrong syringe for insulin. A standardized preparation process, including the correct dosage of insulin in the proper (insulin) syringe, should be taught to students, after which students' performance should be re-evaluated. Although many intravenous medications are given through a drip, not by pushing, in clinical settings students should not assume that all intravenous medications are given by drip. We should educate students to clarify with prescribers any uncertain areas, instead of deviating from medication directions without prescription orders.

Educational preparation for nursing students' safe medication administration and error reporting is an ongoing process of safety culture development throughout the curricula, from introducing knowledge and skills for medication administration in the fundamentals of nursing and practicing in medical and surgical nursing to integrating

that knowledge and those skills in the last year before graduation. Kuo et al. (2020) found that differences in and the complexity of the medication administration process between real practice and knowledge taught in class might be why new nurses make errors or could not recognize them to prevent them from occurring. Additionally, inexperience and distractions are leading causes of performance deficits (Wolf et al., 2006). Transformation of nursing education is needed to prepare students to practice in a continually evolving, complex, and challenging healthcare system (Frenk et al., 2010). Students should go beyond formative (e.g., knowledge and skills) and informative (e.g., professional values) learning to become active agents of change with a vision of patient safety and high-quality care (Pepin et al., 2017). Nursing education outcomes should focus on competence, which includes critical thinking, effective teamwork, safety culture, and integration of global resources into local priorities (Pepin et al., 2017). It will be helpful to include the medication error simulation course in nursing education so that students have opportunities to integrate their knowledge and skills in a safe environment without actually harming patients and be able to identify weak areas for improvement (Kuo et al., 2020).

In the modern world, we are all interdependent on each other. Students from three countries had both similar and different medication errors, so nursing educators should share experiences, resources, and innovations, and partner to build a strong safety culture not just in a single nation but in all countries. Collaboration and support are vital for bringing global resources to local priorities and nourishing our nursing students and future leaders in nursing practice.

5.1. Limitations

Several limitations should be taken into account when interpreting our results. We only investigated one nursing school from each country, and generalizing our study findings to represent an entire country should be done with caution. Future studies should invite more schools to participate and develop effective teaching strategies to develop a culture of medication safety for local nursing students with global resources. Additionally, the types of errors were pre-designed in the scenario for students to identify and correct. Due to the simulation's time limitations, some error types, such as wrong medication calculations, wrong IV injection rates, wrong preparations, etc., were not explored in this study. There is the possibility that errors other than the pre-designed errors might occur during the medication administration process. Nursing faculties still need to carefully monitor each individual student's performance and stop students from making errors in real clinical practicums. Future problem-based simulation scenarios should include other types of errors for students to identify.

6. Conclusions

Medication administration errors are commonly committed among nursing graduands. Nursing faculty should improve medication administration safety by targeting their students' capability to identify and prevent specific medication errors; this is especially true in situations requiring advanced clinical reasoning. International collaboration is encouraged to enhance global safety and minimize local weaknesses.

CRediT authorship contribution statement

Shu-Yu Kuo: Conceptualization, Methodology, Participant recruitment, and Manuscript preparation.

Streerut Thadakant: Conceptualization, Methodology, Participant recruitment, and Manuscript preparation.

Sri Warsini: Conceptualization, Methodology, Participant recruitment, and Manuscript preparation.

Hui-Wen Chen: Data collection, Faculty training, and Manuscript preparation.

Sophia Hu: Conceptualization, Methodology, Manuscript preparation, Statistical analysis, Writing, Revising, and Editing.

Khudazi Aulawi: Methodology, Participant recruitment, and Manuscript preparation.

Sumolchat Duangbubpha: Methodology, Participant recruitment, and Manuscript preparation.

Kusuma Khuwatsamrit: Methodology, Participant recruitment, and Manuscript preparation.

Declaration of competing interest

The authors have no conflicts of interest to declare

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