

Original Research

Look-alike/sound-alike medication errors: An in-depth examination through a hospital case study

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Abstract

Background: Look-alike/sound-alike (LASA) drugs substantially contribute to global healthcare challenges and patient harm, necessitating a comprehensive understanding of LASA medication errors. **Objective:** The current study explored the prevalence and characteristics of medication errors related to LASA in a 200-bed general hospital. **Methods:** A mixed-methods approach was employed. The quantitative component analyzed the LASA drug error data using the hospital database. For the qualitative component, in-depth interviews with pharmacists and pharmacy staff were undertaken to gain insights into stakeholder perceptions and management of LASA-related issues. **Results:** Quantitative analysis highlighted three types of LASA medication errors: confusion due to similar drug names, appearance, and packaging. Drug name confusion accounted for most errors (64.62%), demonstrating the considerable risk associated with similar medication names. Packaging confusion accounted for 24.61% of errors, indicating the importance of a unique packaging design. Overall, 10.77% of errors were attributed to similar appearance, indicating that the visual resemblance of medications played a considerable role in LASA errors. Forty-six LASA drug pairs were identified, the most frequent being simvastatin 10 mg and simvastatin 20 mg. The errors were divided into two categories: Category A, with two pairs related to name and packaging similarities, and Category B, with 44 pairs involving all types of similarities. The differentiation between these categories underscores the complex nature of LASA errors. Semi-structured interviews revealed that anticipatory errors often occurred during busy periods, which could result in crucial details, such as drug strengths, being overlooked. Proposed solutions for reducing LASA errors included implementing Tall Man lettering, developing movable LASA signage, and improving workforce allocation. Root-cause analysis identified several factors, including drug similarities and staffing issues, as notable contributors to LASA errors, highlighting the need for a multi-pronged approach. **Conclusion:** LASA medication errors, particularly those attributed to drug name similarities, pose a considerable risk and persist despite existing safeguards. Implementing tailored strategies, such as Tall Man letters, movable LASA signage, and careful management of high-risk medication pairs, could aid in addressing these issues.

Keywords: look-alike sound-alike (LASA); medication error; hospital; Thailand

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INTRODUCTION

Medication errors continue to pose considerable risks to patient safety in healthcare.¹ “To Err Is Human” emphasizes the importance of drawing lessons from these mistakes to enhance patient safety and establish a safer health system.² Look-alike/sound-alike (LASA) medication errors remain a substantial concern owing to their potential for harm, especially among patients taking multiple medications.³ These errors contribute to 7–20% of all medication errors.^{4,5} In the US, nearly 1.4% of 26,604 LASA errors reported between 2003 and 2006 resulted in patient harm.^{3,6} Approximately 1% of US prescriptions have been associated with LASA errors.^{3,7} Notably, these errors were found to occur when medications share similar names, appearances, or packaging, leading to confusion during administration,^{3,4} resulting in under-dosing, overdosing, or inappropriate dosing, thereby endangering patients and straining healthcare systems.^{8,9} Accordingly, LASA errors stem from illegible handwriting, limited medication knowledge, rapid drug releases, and packaging similarities.⁴

The global importance of LASA errors has been acknowledged by notable organizations like the World Health Organization,



European Medicine Agency, and the Institute for Safe Medication Practices (ISMP).^{5,10-13} Despite ongoing efforts, these errors persist, prompting the need for immediate interventions to enhance medication safety.^{14,15} LASA errors directly compromise patient safety, potentially leading to incorrect medication administration and adverse effects.^{1,9} Importantly, these errors increase healthcare costs owing to extended treatments and hospital stays, impact public confidence in the healthcare system, and can have legal and regulatory implications.^{1,9,16} Recognizing these consequences highlights the relevance of preventive measures to ensure patient safety and maintain healthcare system credibility.^{3,17,18}

Hospitals employ a diverse range of strategies to tackle LASA errors, including Tall Man lettering,^{5,8,19} barcode medication administration technology,^{5,20} automated dispensing systems,^{21,22} medication reconciliation during care transitions,^{5,20} computerized physician order entry to minimize the risks of handwritten prescriptions,²¹ clinical decision support systems to offer LASA error alerts,^{21,23} education and training to update healthcare professionals,²¹ color coding and packaging to distinguish similar medications,¹³ robust labeling for clear drug identification,¹³ two-person verification to double-check accuracy,^{13,24,25} standardized order sets to reduce inconsistencies,^{1,26} mock scenarios to practice error responses, reporting and analysis to prevent future LASA incidents, human factors engineering for safer processes, and regular audits and reviews to ensure protocol adherence.^{3,18,21,27-31} Although these measures can effectively minimize LASA error risks, no system can comprehensively eliminate errors. Combining these approaches with a dedicated focus on patient safety can substantially reduce medication errors in healthcare settings.^{15,29-31} Nonetheless, despite enhanced accuracy and efficiency during dispensing, advanced technologies and systems may pose implementation challenges for resource-limited hospitals.^{18,32}

The Ministry of Public Health, Thailand, acknowledges the importance of LASA drug concerns as a critical issue in medication safety, necessitating preventive measures.³³⁻³⁵ In Thailand, hospitals have independently implemented steps to prevent and alleviate LASA-related errors.^{18,34-36} However, there remains a gap in comprehensive research focused on LASA medication errors within a hospital environment, particularly in terms of their prevalence and characteristics from the viewpoint of pharmacy staff.^{37,38} Accordingly, our investigation is crucial for identifying potential vulnerabilities in medication safety systems and planning targeted interventions to decrease these errors. Moreover, obtaining input from pharmacy staff regarding challenges and potential remedies will furnish valuable insights. With a deeper understanding of LASA medication errors, the current study aimed to explore the frequency and details of LASA medication errors in hospitals.

METHODS

Study design

The current study was performed in a 200-bed general hospital

with an extensive array of 710 unique medication items. Medications were classified into four main categories: tablets/capsules, representing 42.7% (303 items) of the total inventory; parenteral liquids, accounting for 30.4% (216 items); and nonparenteral liquids, accounting for 26.9% (191 items). Given that tablets and capsules constitute a substantial proportion of medications used in hospitals, our study primarily focused on exploring potential LASA errors associated with these specific forms of medications. This study employed a mixed-methods approach to examine LASA-induced medication errors, particularly considering tablet and capsule drugs, in the hospital context.

The quantitative aspect of this research focused on mapping the scope of LASA drug issues. Data related to LASA-associated medication errors were meticulously extracted from the hospital database, offering a comprehensive perspective on the challenges associated with these drugs. The qualitative component of the study sought to gain a nuanced understanding of LASA drug issues within case study hospitals. Moreover, the current study explored how stakeholders perceive and handle LASA-induced complications. This research phase involved an extensive review of documents related to LASA drugs, including drug lists and medication error reports. Interactions with pharmacists and pharmacy staff who manage LASA drugs at the study hospital were also key elements of the qualitative investigation. These involve structured data collection using a custom form and interviews to gather objective evidence and personal experiences linked to LASA drug challenges. The study was approved by the Research Ethics Committee of Ubon Ratchathani University (approval no. UBU – REC – 74/2566).

Study population

Quantitative Research

This quantitative study component collected hospital data on medication errors related to LASA drugs. The data recorded by medical personnel included the names of LASA tablets/capsule drugs, LASA medication error types, and medication error categories. The quantitative research relied on reports of LASA medication errors from the Medication Error Database for the fiscal year 2021.

Qualitative Research

This qualitative study component involved in-depth, one-on-one interviews with key informants from the outpatient pharmacy department. The sample size needed for saturation varied between 5 and 24 interviews, with a minimum of 5 interviews required to achieve saturation.^{39,40} The interviews continued until data saturation was reached and no new information emerged.⁴¹ Participants for this research were selected based on specific criteria: pharmacists or pharmacy staff with a minimum of six months experience in patient service units, involved in addressing LASA drug-related errors, and willing to provide comprehensive insights into these incidents. Data from participants who chose not to answer the questions or who withdrew from the study were excluded. Interviews were conducted until data saturation was achieved and no new information emerged. The research participants



were seven pharmacists and pharmacy staff (n=7 individuals).

Survey instrument

Data were collected from a database of medication error reports obtained from the hospital. A data collection form was created to document LASA medication errors. Another tool used was an interview guide to examine and gain insights into the number of LASA medication errors. To ensure the accuracy and relevance of our data collection tools, we ensured the content validity of the data collection form and interviews guided by three experts.⁴² These experts had considerable experience in patient safety and drug systems. Collected data included the prevalence of LASA errors, types of LASA similarities (e.g., confusion of similar names, similar appearance confusion, and similar packaging confusion), and medication error categories (A–I) according to the National Coordinating Council for Medication Error Reporting and Prevention classification.^{9,43,44} Category A refers to potential errors, B refers to errors that were not delivered to the patient, C and D refer to medication errors that reached the patient without harm, E through H errors denote increasing severity of patient harm, and I errors resulted in fatal outcomes. All error reports from healthcare professionals were validated by the hospital’s risk management board.

During the qualitative phase, in-depth interviews were conducted using a semi-structured interview guide. Information was gathered through voice recordings and meticulous note-taking throughout the interview process.^{45,46} For semi-structured interviews, the following topic guide was employed:

Can you share details regarding your role and experience in the pharmacy department, including how you encountered and managed LASA (Look-alike/sound-alike) drugs?

What challenges and strategies have you faced concerning LASA errors, and how has your hospital worked to reduce their occurrence?

How might services be enhanced to prevent LASA medication errors, and what additional resources or support would benefit you and your colleagues?

Can you describe a specific instance where a LASA error was identified and addressed effectively?

What are your insights into overall medication errors and the future prevention of LASA errors within the pharmacy field?

The researcher’s role was integral to recording attitudes, data analysis, and maintaining clarity of the research objectives. Data were verified through method triangulation, comparing questionnaire and interview data for consistency. Key informants verified the meaning of the analyzed data. The process commenced with a briefing of the pharmacy department heads who had agreed to participate in the study. These pharmacy heads then selected pharmacists and staff members to gather data on medication errors using the forms provided. In collaboration with the pharmacy department, data on LASA drug-related medication errors and their severity were accessed and recorded over 1–2 weeks. Interviews were

conducted with pharmacists and pharmacy staff to delve deeper into LASA medication errors. Each session lasted 30–45 minutes, focusing on the causes and implications of these errors.

Data analysis

Two methods were used for data analysis. Initially, medication error reports associated with LASA pairs were assessed using descriptive statistics, with emphasis on frequency and percentage. Subsequently, the interview data were analyzed using a content analysis approach.⁴⁵ Key points from each interview were identified, indexed, and coded. The coded data were classified into relevant categories. Meanings from these categories were derived and verified prior to reaching conclusions. This approach enhanced the understanding of the qualitative data and complemented the quantitative results, strengthening the overall research outcomes.

RESULTS

Herein, we performed a hospital case study primarily focused on LASA medications and their association with medication errors.

The quantitative analysis examined three types of LASA medication errors, i.e., similar drug name confusion, similar tablets/capsule appearance confusion, and similar packaging confusion. Similar drug name confusion or errors accounted for the highest percentage of errors (64.62%), indicating a substantial risk of confusion caused by similar medication names. Incorrect strength errors contributed to a similar error percentage, highlighting the potential for harm when selecting incorrect drug strengths owing to name similarities (Table 1). Similar packaging confusion accounted for 24.61% of the errors, indicating the importance of packaging design to avoid medication errors. Additionally, similar appearance errors constituted 10.77% of the total errors, suggesting that the visual resemblance between medications plays a notable role in LASA medication errors.

Overall, 46 pairs of LASA drugs were identified, each marked by resemblance in name, packaging, or appearance. The pair recorded most frequently was simvastatin 10 mg and simvastatin 20 mg, encountered 30 times, underscoring the substantial potential for confusion owing to the similarity in drug names. This potential is further exacerbated by the identical starting letter “S” in both drug names and their common roles

Table 1. Type of LASA medication errors (n=46 drug pairs)		
Type of LASA medication errors	Frequency*	Percentage
1. Similar drug name confusion	42	64.62
2. Similar packaging confusion	16	24.61
3. Similar appearance (tablets/capsules) confusion	7	10.77
Total	65	100

*A single pair of drugs might be associated with multiple types of LASA medication errors.



as lipid-lowering agents. Such similarities can lead to confusion among staff members, particularly when inadequate attention is paid to the strength of the medication. The LASA drug pair with the second highest frequency was amlodipine 5 mg and amlodipine 10 mg, with 18 occurrences. The key cause for these errors was that both drugs begin with the letter "A." Staff familiarity with a specific product type often resulted in a lack of label scrutiny, especially in terms of medication strength.

Furthermore, the errors were divided into two categories: A and B. Category A comprised confusion related to similarities in names and packaging and involved only two pairs. Conversely, Category B, which included confusion originating from all three types of similarities, encompassed 44 pairs. The nuanced differentiation between these categories further elucidated the complex nature of LASA errors in hospital settings, as detailed in Table 2. In the qualitative component, the outpatient pharmacy department was evaluated. Based on the dispensing workload over the fiscal year, 167,587 prescriptions were processed, resulting in 620,970 dispensed items. On average, there were approximately 373 prescriptions per day, each comprising an average of 3.87 items. The outpatient pharmacy department was represented by 10 staff members: three pharmacists, three pharmacy technicians, and four pharmacy general officers. Regarding the qualitative aspect of the study, we focused on the experiences of the staff within this department, with seven participants (four males and three females) actively involved in this in-depth exploration. Table 3 summarizes the detailed characteristics of the participants.

Pharmacists within the pharmacy department fulfilled critical functions, including screening prescriptions, dispensing medications, and providing patient counseling. These roles ensured accuracy and safety in medication dispensing and contributed to overall patient care. Pharmacy technicians supported pharmacists in these efforts, focusing on routine, non-complex tasks, such as organizing and dispensing medications according to prescriptions and offering advice on medication use. To qualify, students must graduate with a Certificate in Public Health Science (Pharmacy Technician). Their work was closely supervised by the pharmacists, which reinforced the integrity of their operations. General pharmacy officers were tasked with dispensing and pre-packaging medications, preparing and cleaning equipment, organizing medications according to prescriptions, managing inventory storage, verifying compliance with standard temperatures in the medication storage room, and ensuring the accuracy and completeness of the medicine inventory.

Regarding the dispensing process, the outpatient pharmacy service adhered to an organized six-step procedure, as depicted in Figures 1–2:

Patients or their relatives present an ID card and obtain a numbered queue card for medication collection.

Pharmacy staff print prescription labels, sort medications into color-coded baskets according to patient treatment rights, and send them to drug preparation areas.

Pharmacists or pharmacy staff prepare prescribed medications, place them in corresponding baskets, align them with the patient's queue number, and manage designated drug shelves (2–3 shelves per person).

A designated area for ready-to-dispense medications is used to check for errors before the medications are sent to a dispensing pharmacist. Any identified error is corrected promptly.

The filled baskets are sent to the dispensing pharmacist for a final check. Any identified errors are immediately fixed, followed by final verification with the patient according to the queue number, including a double-check of information.

Medication is dispensed to the patient, accompanied by guidance and advice regarding the prescribed medications.

The feedback gathered from the semi-structured interviews was organized and divided into three themes, each relating to experiences with LASA drugs, as follows:

Characteristics of Pharmacy Operations: The efficiency of the pharmacy staff was closely related to their habitual work patterns. Medications were systematically arranged alphabetically and based on drug type, including tablets, external applications, high-value drugs, and liquids. On average, pharmacy staff typically require a week to gain familiarity with the operational routine of each pharmacy, highlighting the variance in organizational methods across different pharmacies.

"We become more efficient the more familiar we are with our process. We categorize medications alphabetically and by type, and we rotate departments every six months. It typically takes us a week to adjust to each new department." (Participant 1, pharmacist)

Occurrence of Anticipatory Errors: The interview data revealed that errors often originate when staff deals with high volumes of cases, resulting in key details, such as drug strengths, being overlooked. This can lead to the misclassification of drugs with the same name but of different strengths or hastened drug storage, leading to incorrect classification. Common pairs that were prone to misclassification included 5 and 10 mg amlodipine, 10 and 20 mg simvastatin, and 500 and 850 mg metformin. Other factors contributing to errors included inadequate reading of drug labels, excessive crowding of drug shelves, and underestimation of the potential harm such errors could inflict on patients.

"These mistakes often happen due to busy hours, rushing while dispensing, focusing only on drug names and not on strengths, and having a large number of medications to dispense." (Participant 2, a pharmacy technician)

Potential Solutions for LASA Medication Errors: Several solutions were suggested to counter LASA errors, such as the implementation of Tall Man letters, the development of LASA signage, changes in pharmaceutical providers, augmentation of the workforce, and distinct storage practices for drugs with identical generic names but distinct strengths.

Drug Name 1	Strength 1	Drug Name 2	Strength 2	Frequency	Type of LASA errors (n= 65)					Medication Error Category (A=2, B=44, Total 46)
					1. Similar Drug name confusion (n=42)	2. Similar Appearance (tablets/capsules) confusion (n=7)	3. Similar Packaging confusion (n=16)	Total	%	
Simvastatin	10 mg	Simvastatin	20 mg	30	1	0	0	1	1.6	B
Amlodipine	5 mg	Amlodipine	10 mg	18	1	0	0	1	1.6	B
Ferrous fumarate	200 mg	Folic	5 mg	14	1	0	0	1	1.6	B
Cetirizine	10 mg	Cinnarizine	25 mg	12	1	0	0	1	1.6	B
Enalapril	5 mg	Enalapril	20 mg	12	1	0	1	2	3.1	B
Trihexyphenidyl	2 mg	Trihexyphenidyl	5 mg	10	1	1	0	2	3.1	B
Calcium	600 mg	Calcium	1250 mg	9	1	0	0		1.6	B
Furosemide	40 mg	Furosemide	500 mg	6	1	0	0	1	1.6	B
Simvastatin	10 mg	Simvastatin	20 mg	5	1	0	0	1	1.6	B
Amoxycillin and clavulanic acid	Amoxycillin 500 mg and clavulanic acid 125 mg	Amoxycillin and clavulanic acid	Amoxycillin 875 mg and clavulanic acid 125 mg	5	1	1	1	1	4.7	B
Risperidone	1 mg	Risperidone	2 mg	3	1	1	0	3	3.1	B
Amlodipine	5 mg	Atenolol	50 mg	3	1	0	1	2	3.1	B
Levothyroxine	0.05 mg	Levothyroxine	0.1 mg	3	1	0	0	2	1.6	B
Haloperidol	5 mg	Haloperidol	0.5 mg	3	1	0	0	1	1.6	B
Rifampicin	300 mg	Rifampicin	450 mg	3	1	1	2	1	6.3	B
Azithromycin	250 mg	Azathioprine	50 mg	2	1	0	0		1.6	B
Sulfasalazine	500 mg	Sertraline	50 mg	2	1	0	0	4	1.6	B
Amitriptyline	10 mg	Amitriptyline	25 mg	2	1	0	0	1	1.6	B
Atenolol	50 mg	Allopurinol	100 mg	2	1	0	1	1	3.1	B
AZT	100 mg	AZT	300 mg	2	1	0	1	1	3.1	B
CPM	4 mg	Bromhexine	8 mg	2	0	1	0	2	1.6	B
CPM	4 mg	CPM and phenylephrine	CPM 4 mg+ phenylephrine 10 mg	2	1	0	0	2	1.6	B
Ferrous fumarate	200 mg	Furosemide	40 mg	2	1	0	0	1	1.6	B
Methimazole	5 mg	Methotrexate	2.5 mg	2	1	0	0	1	1.6	B
Norfloxacin	100 mg	Norfloxacin	400 mg	2	1	0	0	1	1.6	B
Prazosin	2 mg	Prazosin	1 mg t	2	1	0	1	1	3.1	B
Spironolactone	25 mg	Glipizide	5 mg	1	0	0	1	1	1.6	B
Colchicine	0.6 mg	Atenolol	50 mg	1	1	0	1	2	3.1	B
Alfuzosin SR	10 mg	Alfacalcidol	0.25 mcg	1	1	0	0	1	1.6	B
Amitriptyline	25 mg	Nortriptyline	25 mg	1	1	0	0	2	1.6	B
Amlodipine	10 mg	Amitriptyline	10 mg	1	1	0	0	1	1.6	B
Amlodipine	10 mg	Atenolol	50 mg	1	1	0	0	1	1.6	B
Aspirin	81 mg	Aspirin	300 mg	1	1	0	0	1	1.6	B
Atenolol	50 mg	Metoprolol	100 mg	1	1	0	0	1	1.6	B
Bromhexine	8 mg	Betahistine	6 mg	1	1	0	0	1	1.6	B

Table 2. LASA drugs (n= 46 pairs)										
Drug Name 1	Strength 1	Drug Name 2	Strength 2	Frequency	Type of LASA errors (n= 65)					Medication Error Category (A=2, B=44, Total 46)
					1.Similar Drug name confusion (n=42)	2. Similar Appearance (tablets/ capsules) confusion (n=7)	3. Similar Packaging confusion (n=16)	Total	%	
Calcium	1250 mg	Carvedilol	12.5 mg	1	1	0	0	1	1.6	B
Cefixime	100 mg	Cetirizine	10 mg	1	1	0	0	1	1.6	B
Sodium valproate	500 mg	Sodium valproate	200 mg	1	1	0	1	1	3.1	B
Flunarizine	5 mg	Fluoxetine	20 mg	1	1	0	0	1	1.6	B
Griseofulvin	500 mg	Gemfibrozil	300 mg	1	1	0	0	2	1.6	B
Thioridazine	100 mg	Thioridazine	10 mg	1	1	1	0	1	3.1	B
Warfarin	2 mg	Warfarin	4 mg	1	1	0	1	1	3.1	B
Warfarin	5 mg	Warfarin	2 mg	1	1	0	1	2	3.1	B
Colchicine	0.6 mg	Allopurinol	100 mg	1	0	1	1	2	3.1	B
Perphenazine	8 mg	Glipizide	5 mg	1	0	0	1	2	1.6	A
Paracetamol	500 mg	Paracetamol and orphenadrine	Paracetamol 450 mg and orphenadrine 35 mg	1	1	0	1	2	1.6	A
				178	42	7	16	65	100	

*Please note that the grouping of medications into similar names, similar packaging, and similar shape is subjective and based on the provided information.

Table 3. Characteristics of the seven key participants (n=7)				
Participants	Gender	Occupation	Education	Year of experiences
1	Female	Pharmacist	Master’s Degree in Clinical Pharmacy	11
2	Female	Pharmacy technician	The Diploma Pharmacy Technician Program (3-years program)	13
3	Male	Pharmacy technician	The Diploma Pharmacy Technician Program (3-years program)	3
4	Female	Pharmacy staff	Bachelor of Business Administration	6
5	Male	Pharmacy staff	Bachelor of Community Health	5
6	Male	Pharmacy staff	Bachelor of Industrial Computing	17
7	Male	Pharmacy staff	Senior high School	5



Figure 1. Dispensing process in the pharmacy department for outpatients.
(Photo credit: This photograph was taken by Ms. Ananya Songmueang, one of the researchers involved in the study).

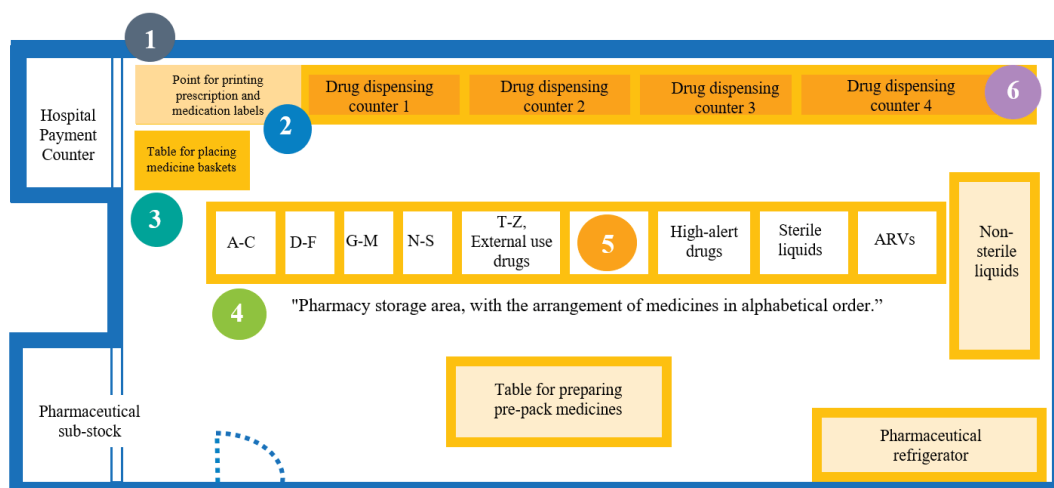


Figure 2. Floor plan of the outpatient pharmacy department. The numbered markers (1–6) correspond to different stages of the dispensing process, as detailed in Figure 1. Medications on the shelves are arranged alphabetically (A–Z), and ARV refers to antiretroviral drugs.

Tall Man letters

Tall Man letters, recognized as uppercase letters, are a common strategy used in healthcare to reduce LASA medication errors. This method employs capital letters to distinguish products with similar names, thus emphasizing their differences. Lists of Tall Man letters are available in hospitals, and their use in medication labeling and storage bins contributes to improved medication safety. However, despite its utility, Tall Man letters is not a standalone solution for preventing LASA errors. It should be employed alongside other strategies, such as enhanced staff training, barcode scanning, and systematic checks to promote safe medication administration. Interestingly, four of five pharmacy staff members believed that Tall Man lettering heightened the ambiguity surrounding similar medication names rather than reducing it; however, this sentiment was not shared by all, with one pharmacy staff member reporting no confusion. Accordingly, while strategies such as Tall Man letters are generally helpful, their implementation and efficacy can be subjective and vary among individuals.

“Occasionally, the ‘Tall Man letters’ deployed on the drug shelves can induce confusion.” (Participant 5, a pharmacy staff member.)

Figure 3 shows two yellow labels that illustrate the use of capital letters to emphasize differences between similar medication names, a method often referred to as “Tall Man letters.” The labels clearly differentiate between two medications, “PheNobarb” and “PerPhenaZine,” emphasizing the unique portions of each name with capitalized letters.

Development of LASA signage

The development of LASA signage was suggested in response to observed medication errors (Figure 4). Existing LASA signage, introduced to warn or raise staff awareness regarding the potential confusion between similar-looking or sounding medications, was inconvenient in practice. The traditional



Figure 3. The application of “Tall Man letters” to differentiate similar medication names, specifically, “PheNobarb” and “PerPhenaZine.” (Photo credit: The photograph is taken by researchers conducting this study.)

stationary nature of these signs has proven to be a notable obstacle. It was difficult to move the signs around according to changes in the medication inventory, leading to outdated or misplaced warnings and, ultimately, a less effective strategy.

“I think the current LASA signs aren’t working well. It’s hard to move them every time the medication inventory changes, which often leads to the signs being outdated or misplaced.” (Participant 7, pharmacy staff).

To overcome this issue, the development of magnetic or easily movable LASA signs has been suggested, which would allow enhanced flexibility in positioning these signs, rendering them



Figure 4. A sign illustrating the look-alike/sound-alike (LASA) drug alert concept on a pharmacy department's drug shelf. (Photo credit: The image originates from a photography collection of researchers conducting this study).

more adaptable to changes in the drug storage area. These modifications could increase the visibility of warnings and make it more convenient for staff to update the sign location as necessary, thereby maintaining the relevance of the warnings. This improvement is anticipated to increase the effectiveness of LASA signs in raising staff awareness and reducing medication errors. Further research and user feedback are required to evaluate the efficacy and practicality of the proposed solutions.

Switching pharmaceutical companies: Although switching to alternate pharmaceutical companies was proposed, this was deemed impractical owing to financial limitations and contractual obligations for medication orders.

Augmentation of the workforce: One recommendation is to increase the number of staff members to diminish the risk of errors. Nevertheless, this approach was considered impractical owing to budget constraints and the need for staff to rotate across different departments, particularly during rush hours in the pharmacy department. Busy periods were typically observed from 8:00 a.m. to 10:00 a.m., coinciding with the opening timing of outpatient clinics, and again in the afternoon from 12:00 a.m. to 2:00 p.m., following lunch breaks. During these periods, an influx of patients arriving for appointments or collecting medications contributes to an increased workload and complexity in the pharmacy department.

Separate placement of drugs with identical generic names but distinct potency/strength: Initially, this strategy seemed to reduce LASA errors. However, as time progressed, drugs inevitably ended up being stored in close proximity because of the ease of administration, thereby undoing the intended advantage of this approach.

Additionally, an in-depth root-cause analysis of each LASA medication pair was performed by conducting detailed

interviews. Examples of LASA errors for various drug pairs are listed below.

Case 1: Simvastatin 10 mg (ZIMVA 10[®]) vs. Simvastatin 20 mg (ZIMVA 20[®])

Five reported incidents arose from confusion between the similar-named drugs, simvastatin 10 mg and simvastatin 20 mg. Simvastatin is a well-known 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase inhibitor used to treat hyperlipidemia. Four key factors were identified as causes of these errors. First, the similar starting letter "S" in both drug names and their shared purpose as lipid-lowering agents can confuse staff if they fail to thoroughly ascertain the strength of the medication. Additionally, the similar secondary packaging size exacerbated this confusion. Older pharmacy staff experiencing vision issues further compounded these problems, as they might struggle to read labels and correctly identify drug strengths. To address this issue, older staff members were assigned packaging duties instead of medication management. Second, insufficient staffing can escalate these errors. To resolve this issue, the medication organization was reassigned to more experienced staff members. Finally, frequent staff rotation creates a challenging environment for newcomers, increasing the likelihood of making mistakes.

Case 2: Amlodipine 5 mg vs. Amlodipine 10 mg

The second case study was centered on the LASA pair of amlodipine 5 mg and amlodipine 10 mg. There were 18 notable instances of confusion between these two drug types, all category B errors. The main reason for these errors was that both drugs begin with the letter "A". Staff members often became familiar with a specific product type, resulting in inadequate attention to respective labels, particularly the medication strength. This lack of attention can frequently

result in the dispensing of inappropriate dosages.

Case 3: Warfarin 5 MG vs. Warfarin 2 MG

Two types of warfarin, were erroneously confused for each other owing to their similar packaging. The error was attributed to the look-alike packages of both drugs, apart from the color and text of the tablets. Using identical blister packs to dispense these drugs can make it difficult to determine the differences in tablet colors, leading to confusion and subsequent errors. These errors could be avoided by changing the packaging to ensure unique drug packaging or improving staff training and awareness regarding these potential issues.

Case 4: Trihexyphenidyl hydrochloride 2 mg vs. Trihexyphenidyl hydrochloride 5 mg

The LASA mix-up between trihexyphenidyl hydrochloride 2 mg and trihexyphenidyl hydrochloride 5 mg largely was mainly attributed owing to the resemblance in their physical attributes, including indistinguishable sizes, white color, and round tablets, which introduced confusion and resulted in improper dispensing of these medications.

DISCUSSION

The current study provides notable insights into hospital medication management, particularly concerning the high rate (64.62%) of medication errors resulting from similar drug names. Our findings highlight the urgent need for improvements in drug labeling and nomenclature to reduce confusion. Reportedly, visual or phonetic resemblances between drug names can result in LASA medication errors.^{15,47,48} According to United States Pharmacopoeia (USP), over 3170 pairs of analogous generic and brand drug names approved in the US have led to misunderstandings among healthcare professionals. A study using USP medication error reporting systems found that 1.4% of errors related to LASA drugs could harm patients.⁴⁹

Since 2008, the ISMP has promoted a strategy to identify LASA drug names by maintaining a list of such names and suggesting the use of Tall Man lettering; this involves a combination of upper- and lower-case letters to help highlight the differences in identified drug names. The list primarily encompasses pairs of generic drug names but also contains some brand-to-brand or brand-to-generic pairs. Echoing this initiative, the US Food and Drug Administration initiated the Name Differentiation Project, advocating for the adoption of "Tall Man" writing as a measure to reduce LASA errors.^{50,51}

In the present study, the two most frequently confused drug pairs, i.e., simvastatin 10 mg and simvastatin 20 mg and amlodipine 5 mg and amlodipine 10 mg, emphasize the need for clear distinctions between similar medication names and dosages. The risks associated with these drug pairs can be exacerbated by their phonetic and visual resemblance and their therapeutic similarity.⁵⁰ The complex nature of medication errors arising from drug name confusion incorporates elements such as similar spellings and pronunciations, often resulting in incorrect prescriptions or dispensing of medications.^{19,22,48} Further analysis revealed that the potential for confusion, and

thereby errors, increased when different products shared the same dosage strength. This finding is consistent with that of Filik et al. (2006), highlighting the considerable role of name and dosage confusion in causing medication errors in healthcare environments.⁴⁷ This is further corroborated by Chanakit et al. (2013), who investigated identical drug lists in Thai hospitals and found that the most prevalent issue was related to similar generic drug names.⁵²

Despite recurring safety concerns, a global policy to ensure the unique naming of innovative medicines has yet to be established.⁵³ The persistent confusion associated with these drug pairs may indicate inadequate staff training or ineffective medication labeling.^{8,15} Therefore, targeted interventions in these areas may be valuable in improving patient safety and reducing medication errors.

Furthermore, errors in medication owing to similar packaging (24.61%) and appearance (10.77%) substantially contributed to LASA errors. Although less prominent than name confusion, medication errors due to similar packaging and appearance represent substantial proportions of total errors, thereby warranting a reevaluation of packaging standards and practices. Likewise, Flynn et al. (2016) have suggested that medication errors could be minimized by adopting standardized packaging and clear dosage markings.¹⁵

The roles and responsibilities of different pharmacy staff members, including pharmacists, pharmacy technicians, and general officers, are well-outlined. These roles, with clearly defined responsibilities, help ensure accuracy and safety in medication dispensing, aligning with best practice guidelines.⁵⁴⁻⁵⁶ Despite these roles and systemic checks and balances, LASA medication errors occur, underscoring the need for further safety measures.⁸

The characteristics of pharmacy operations, anticipatory errors, and potential solutions to reduce LASA medication errors were the main themes identified in the staff experience with LASA drugs. Pharmacy operations can markedly affect the efficiency and safety of medication dispensing. The key to efficient operations is medication arrangement based on alphabetical order, drug types, and habituation to pharmacy routines.^{57,58}

Anticipatory errors, especially during busy periods, remained a major concern, as staff may overlook crucial details, such as drug strength, leading to dispensing errors. This finding aligns with that reported in previous research highlighting the heightened risk of errors during periods of high workload.^{4,59} Therefore, workload management and adequate staffing during peak hours can be considered possible solutions. Moreover, worker fatigue can impact the performance of health workers, leading to additional errors.⁶⁰ Reducing the burden on pharmacists can minimize dispensing errors. Consequently, continuous efforts to maintain pharmacists' workloads at manageable levels are crucial to maintaining the quality of prescriptions.^{61,62}

Furthermore, the staff suggested solutions to counter LASA drug pairs, such as the application of Tall Man letters, development of LASA signage, changing pharmaceutical providers, augmentation of the workforce, and distinct storage practices for drugs with identical generic names but varied



potencies. The ISMP supports the Tall Man lettering strategy to reduce medication errors.^{12,63} However, some staff members felt that this strategy occasionally introduces additional confusion.¹³ Accordingly, although standardized strategies can provide general guidance, they may need to be tailored to individual settings and populations to ensure effectiveness.⁶⁴ Interestingly, an in-depth analysis of each LASA medication pair revealed specific causes leading to errors. Strategies such as altered packaging, enhanced staff training, attention to label reading, and attention to specific and commonly confused drugs were suggested to reduce these errors, consistent with previous research.⁶⁵

Our study enhances the current understanding of LASA medication errors by providing both quantitative and qualitative insights from a 200-bed general hospital, reflecting scenarios in resource-limited hospitals lacking advanced systems, such as automated drug dispensing and computerized alerts.^{62,66,67} In addition, our findings from the 2021 medication error database were contextualized by the COVID-19 pandemic's impact on hospital settings. The pandemic exacerbated workloads and complicated medication and supply management, leading to increased working hours for healthcare providers. Additionally, there was a notable increase in dispensing activities, with medicines being distributed to primary care units and patients' homes, as well as through community pharmacies involved in near-home pick-up services. These pandemic-induced changes may have significant implications for medication errors. Using a mixed-methods approach that analyzes hospital data and conducts interviews, the study provides a comprehensive overview, identifying 46 LASA drug pairs, categorizing errors, and suggesting possible solutions. Nevertheless, its scope was limited because it focused on a single hospital and predominantly on tablets and capsules, potentially neglecting other drug forms and broader contexts. Future research should expand into diverse settings, examine various medication forms, and consider technological solutions such as drug verification driven by artificial intelligence.

CONCLUSIONS

The findings of the present study highlight the multifaceted nature of LASA medication errors, with particular attention to complexities arising from similarities in drug names, appearance, and packaging. These results indicate the critical need for robust procedures and guidelines for medication selection, administration, and packaging design to mitigate the risks associated with LASA errors. In conclusion, although systematic checks and balances exist in pharmacy departments, LASA medication errors continue to occur, necessitating further safety measures. Tailoring strategies such as the Tall Man letters, LASA signage, and other measures aimed at the specific needs of individual settings, along with attention to workload management and focusing on high-risk LASA medication pairs, may help reduce these errors.

CONFLICTS OF INTEREST

None

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AUTHOR CONTRIBUTIONS

Teeraporn Supapaan: Conceptualization, Methodology, Data collection, Formal analysis, Writing-original draft preparation; Ananya Songmuang: Data collection, Validation, Writing-reviewing and editing; Jintana Napaporn: Conceptualization, Formal analysis, Writing-reviewing and editing; Parichat Sangsukwong: Data collection, Formal analysis; Pornchanok Boonrod: Data collection, Formal analysis; Phonrawin Intarapongsakul: Data collection, Formal analysis; Aporn Jaturapattarawong: Validation, Writing-reviewing and editing; Chonladda Pitchayajittipong: Methodology, Formal analysis, Writing-original draft preparation.

References

1. Rodziewicz TL, Houseman B, Hipskind JE. Medical Error Reduction and Prevention. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023.
2. Institute of Medicine Committee on Quality of Health Care in A. To Err is Human: Building a Safer Health System. In: Kohn LT, Corrigan JM, Donaldson MS, editors. Washington (DC): National Academies Press (US); 2000.
3. Lizano-Díez I, Figueiredo-Escribá C, Piñero-López M, et al. Prevention strategies to identify LASA errors: building and sustaining a culture of patient safety. *BMC Health Serv Res*. 2020;20(1):63. <https://doi.org/10.1186/s12913-020-4922-3>
4. Schnoor J, Rogalski C, Frontini R, et al. Case report of a medication error by look-alike packaging: a classic surrogate marker of an unsafe system. *Patient Saf Surg*. 2015;9:12. <https://doi.org/10.1186/s13037-014-0047-0>
5. WHO Collaborating Centre for Patient Safety Solutions. (2007). Look-Alike, Sound-Alike Medication Names. https://cdn.who.int/media/docs/default-source/patient-safety/patient-safety-solutions/ps-solution1-look-alike-sound-alike-medication-names.pdf?sfvrsn=d4fb860b_8. Accessed 9 August, 2023.
6. Hicks R, Becker S, Cousins D. MEDMARX data report. A report on the relationship of drug names and medication errors in response to the institute of Medicine's call for action Rockville: Center for the Advancement of Patient Safety, US Pharmacopeia. 2008.
7. Flynn EA, Barker KN, Carnahan BJ. National observational study of prescription dispensing accuracy and safety in 50 pharmacies. *J Am Pharm Assoc (Wash)*. 2003;43(2):191-200. <https://doi.org/10.1331/108658003321480731>



8. Bryan R, Aronson JK, Williams AJ, et al. A systematic literature review of LASA error interventions. *Br J Clin Pharmacol*. 2021;87(2):336-351. <https://doi.org/10.1111/bcp.14644>
9. Tariq RA, Vashisht R, Sinha A, et al. Medication Dispensing Errors And Prevention. StatPearls. Treasure Island (FL): StatPearls Publishing; 2021. <http://www.ncbi.nlm.nih.gov/books/nbk519065/>
10. Institute for Safe Medication Practices (ISMP). (2009). Survey on LASA drug name pairs: who knows what's on your list and the best ways to prevent mix-ups? Accessed 15 May, 2023.
11. The World Health Organization. (2007). WHO launches 'Nine patient safety solutions'. <https://www.who.int/news/item/02-05-2007-who-launches-nine-patient-safety-solutions>. Accessed 12 Aug, 2022.
12. Institute for Safe Medication Practices (ISMP). (2019). ISMP List of Confused Drug Names. <https://www.ismp.org/recommendations/confused-drug-names-list>. Accessed 11 Oct, 2022.
13. Larmen -Beld KHM, Alting EK, Taxis K. A systematic literature review on strategies to avoid look-alike errors of labels. *Eur J Clin Pharmacol*. 2018;74(8):985-993. <https://doi.org/10.1007/s00228-018-2471-z>
14. Ostini R, Roughead EE, Kirkpatrick CM, et al. Quality Use of Medicines--medication safety issues in naming; look-alike, sound-alike medicine names. *Int J Pharm Pract*. 2012;20(6):349-357. <https://doi.org/10.1111/j.2042-7174.2012.00210.x>
15. Bryan R, Aronson JK, Williams A, et al. The problem of look-alike, sound-alike name errors: Drivers and solutions. *Br J Clin Pharmacol*. 2021;87(2):386-394. <https://doi.org/10.1111/bcp.14285>
16. Salhotra R, Tyagi A. Medication errors: They continue. *J Anaesthesiol Clin Pharmacol*, 2019;35(1):1-2.
17. World Health Organization. Towards eliminating avoidable harm in health care. Global patient safety action plan. 2021;2030.
18. Chumchit C, Amrumpai Y, Treesak C. Recognition on medication safety and look-alike/sound-alike medication problems in Thai public hospitals. *Silpakorn U Science & Tech J*. 2015;9(2):40-51.
19. Filik R, Price J, Darker I, et al. The influence of tall man lettering on drug name confusion: a laboratory-based investigation in the UK using younger and older adults and healthcare practitioners. *Drug safety*. 2010;33:677-687. <https://doi.org/10.2165/11532360-000000000-00000>
20. Cheng CM, Salazar A, Amato MG, et al. Using drug knowledgebase information to distinguish between look-alike-sound-alike drugs. *J Am Med Inform Assoc*. 2018;25(7):872-884. <https://doi.org/10.1093/jamia/ocy043>
21. Billstein-Leber M, Carrillo CJD, Cassano AT, et al. ASHP Guidelines on Preventing Medication Errors in Hospitals. *American Journal of Health-System Pharmacy*.2018;75(19):1493-1517. <https://doi.org/10.2146/ajhp170811>
22. Lambert BL, Galanter W, Liu KL, et al. Automated detection of wrong-drug prescribing errors. *BMJ Qual Saf*. 2019;28(11):908-915. <https://doi.org/10.1136/bmjqs-2019-009420>
23. Galanter WL, Bryson ML, Falck S, et al. Indication Alerts Intercept Drug Name Confusion Errors during Computerized Entry of Medication Orders. *PLOS ONE*. 2014;9(7):e101977. <https://doi.org/10.1371/journal.pone.0101977>
24. Schwappach DLB, Yvonne P, Katja T. Medication double-checking procedures in clinical practice: a cross-sectional survey of oncology nurses' experiences. *BMJ Open*. 2016;6(6):e011394. <https://doi.org/10.1136/bmjopen-2016-011394>
25. Alyami MH, Naser AY, Alswar HS, et al. Medication errors in Najran, Saudi Arabia: Reporting, responsibility, and characteristics: A cross-sectional study. *Saudi Pharm J*. 2022;30(4):329-336. <https://doi.org/10.1016/j.jsps.2022.02.005>
26. Grissinger M. Guidelines for standard order sets. *P t*, 2014;39(1):10-50. <http://www.ncbi.nlm.nih.gov/pmc/articles/pmc3956384/>
27. Dhawan I, Tewari A, Sehgal S, et al. Medication errors in anesthesia: unacceptable or unavoidable?. *Braz J Anesthesiol*. 2017;67(2):184-192. <https://doi.org/10.1016/j.bjane.2015.09.006>
28. Cohen MR, Smetzer JL. ISMP Medication Error Report Analysis. *Hospital Pharmacy*. 2018;53(4):217-219. <https://doi.org/10.1177/0018578717715346>
29. Cohen MR, Smetzer JL. No Unlabeled Containers Anywhere, Ever! Where Did this Come From?. *Hospital Pharmacy*. 2015;50(3):185-188. <https://doi.org/10.1310/hpj5003-185>
30. Cohen MR. Maalox Brand Name Extension Causes Confusion Near Sight/Sound Dead Hit! Omacor–Amicar Look-alike Tylenol Packets. *Hospital Pharmacy*. 2006;41(1):13-16.
31. Cohen MR. Another Purpose for "Purpose" Look-Alike Unit-Dose Containers Mixed up Misinterpretation of Sliding-Scale Insulin Dose. *Hospital Pharmacy*. 2001;36(12):1132-1133.
32. Thirumagal M, Ahamedbari MAR, Samaranayake NR, et al. Pattern of medication errors among inpatients in a resource-limited hospital setting. *Postgrad Med J*. 2017;93(1105):686-690. <https://doi.org/10.1136/postgradmedj-2017-134848>
33. Limpayalert P. (2017). 2P Safety patient and personnel safety. https://hacc.kku.ac.th/haccupload_news/pdftitle/Tue24545uFpjMOP.pdf. Accessed 02 Jan, 2022.
34. Wongboonnak P. Look-alike sound-alike drugs situation in Thailand. *HCU Journal of Health Science*. 2018;22:205-216.
35. Wongboonnak P. Resolving the Problems on Look-Alike Sound-Alike Drugs at the System Level. *Thai Journal of Pharmacy Practice*. 2017;9(1):251-258.
36. Chanakit T, Napaporn J, Chiempattanajakohn T, et al. The survey of look alike/sound alike (LASA) drugs available in hospitals in Thailand. *Afr J Pharm Pharmacol*. 2013;7(6):227-239.
37. Stewart D, Thomas B, MacLure K, et al. Perspectives of healthcare professionals in Qatar on causes of medication errors: A mixed methods study of safety culture. *PLoS One*. 2018;13(9):e0204801. <https://doi.org/10.1371/journal.pone.0204801>



38. Guchelaar HJ, Colen HB, Kalmeijer MD, et al. Medication errors: hospital pharmacist perspective. *Drugs*. 2005;65(13):1735-1746. <https://doi.org/10.2165/00003495-200565130-00001>
39. Constantinou CS, Georgiou M, Perdikiogianni M. A comparative method for themes saturation (CoMeTS) in qualitative interviews. *Qualitative research*. 2017;17(5):571-588. <https://doi.org/10.1002/jgc4.1399>
40. Hennink M, Kaiser BN. Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social Science & Medicine*. 2022;292:114523. <https://doi.org/10.1016/j.socscimed.2021.114523>
41. Saunders B, Sim J, Kingstone T, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant*. 2018;52(4):1893-1907. <https://doi.org/10.1007/s11135-017-0574-8>
42. Azraii AB, Ramli AS, Ismail Z, et al. Validity and reliability of an adapted questionnaire measuring knowledge, awareness and practice regarding familial hypercholesterolaemia among primary care physicians in Malaysia. *BMC Cardiovascular Disorders*. 2021;21(1):39. <https://doi.org/10.1186/s12872-020-01845-y>
43. National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP). (2022). Types of medication errors. <https://www.nccmerp.org/types-medication-errors> Accessed 11 October, 2022.
44. Dos Santos L, Winkler N, Dos Santos MA, et al. Description of medication errors detected at a drug information centre in Southern Brazil. *Pharm Pract (Granada)*. 2015;13(1):524. <https://doi.org/10.18549/pharmpract.2015.01.524>
45. Chan HK, Hassali MA, Lim CJ, et al. Improving pediatric liquid medication labeling of the hospital information system in Malaysia: qualitative analysis of pharmacists' perceptions. *Pharm Pract (Granada)*. 2016;14(2):699. <https://doi.org/10.18549/pharmpract.2016.02.699>
46. Treejan K, Jinatongthai P, Moolasarn S, et al. Self-health care behaviors and knowledge of youth living with HIV. *J Am Pharm Assoc* (2003). 2022;62(4):1249-1259.e1247. <https://doi.org/10.1016/j.japh.2022.02.006>
47. Filik R, Purdy K, Gale A, et al. Labeling of medicines and patient safety: evaluating methods of reducing drug name confusion. *Hum Factors*. 2006;48(1):39-47. <https://doi.org/10.1518/001872006776412199>
48. Filik R, Purdy K, Gale A, et al. Drug name confusion: evaluating the effectiveness of capital ("Tall Man") letters using eye movement data. *Soc Sci Med*. 2004;59(12):2597-2601. <https://doi.org/10.1016/j.socscimed.2004.04.008>
49. Thompson CA. USP says thousands of drug names look or sound alike. *American Journal of Health-System Pharmacy*. 2008;65(5):386-388. <https://doi.org/10.2146/news080020>
50. U.S. Department of Health and Human Services: Food and Drug Administration. (2016). From our perspective: Working to prevent proprietary drug name confusion. <https://www.fda.gov/drugs/news-events-human-drugs/our-perspective-working-prevent-proprietary-drug-name-confusion> . Accessed 01 August, 2023.
51. U.S. Department of Health and Human Services Food and Drug Administration (FDA). (2020). FDA name differentiation project. <https://www.fda.gov/drugs/medication-errors-related-cder-regulated-drug-products/fda-name-differentiation-project> . Accessed 06 Aug, 2023.
52. Chanakit T, Napaporn J, Chiempattanakajohn T, et al. The survey of look alike/sound alike (LASA) drugs available in hospitals in Thailand. *Afr J Pharm Pharmacol*. 2013;7(6):227-239.
53. Reines SA. Look-alike, sound-alike drug errors with Reminyl and Amaryl. *American Journal of Health-System Pharmacy*. 2005;62(1):35-36. <https://doi.org/10.1093/ajhp/62.1.35>
54. Ságiné EP, Romvári Z, Dormán K, et al. Your clinical pharmacist can save your life, the impact of pharmacist's intervention. *Pharm Pract (Granada)*. 2022;20(4):2729. <https://doi.org/10.18549/pharmpract.2022.4.2729>
55. Boughen M, Fenn T. Practice, Skill Mix, and Education: The Evolving Role of Pharmacy Technicians in Great Britain. *Pharmacy (Basel)*. 2020;8(2). <https://doi.org/10.3390/pharmacy8020050>
56. Pote S, Tiwari P, D'Cruz S. Medication prescribing errors in a public teaching hospital in India: A prospective study. *Pharm Pract (Granada)*. 2007;5(1):17-20. <https://doi.org/10.4321/s1886-36552007000100003>
57. Meena DK, Jayanthi M, Ramasamy K, et al. Medicine Storage and Dispensing Facilities in Public Healthcare Pharmacies of Puducherry, India. *Cureus*. 2022;14(1):e21389. <https://doi.org/10.7759/cureus.21389>
58. Ruutiainen HK, Kallio MM, Kuitunen SK. Identification and safe storage of look-alike, sound-alike medicines in automated dispensing cabinets. *European Journal of Hospital Pharmacy*. 2021;28(e1):e151. <https://doi.org/10.1136/ejhpharm-2020-002531>
59. Kc DS, Terwiesch C. Impact of Workload on Service Time and Patient Safety: An Econometric Analysis of Hospital Operations. *Management Science*. 2009;55(9):1486-1498.
60. Scott LD, Rogers AE, Hwang WT, et al. Effects of critical care nurses' work hours on vigilance and patients' safety. *Am J Crit Care*. 2006;15(1):30-37.
61. Shao SC, Chan YY, Lin SJ, et al. Workload of pharmacists and the performance of pharmacy services. *PLoS One*. 2020;15(4):e0231482. <https://doi.org/10.1371/journal.pone.0231482>
62. Alanazi MF, Shahein MI, Alsharif HM, et al. Impact of automated drug dispensing system on patient safety. *Pharm Pract (Granada)*. 2022;20(4):2744. <https://doi.org/10.18549/pharmpract.2022.4.2744>
63. Karet GB. Linguistic Analysis of Generic-Generic Drug Name Pairs Prone to Wrong-Drug Errors for which Tall-Man Lettering is Recommended. *Ther Innov Regul Sci*. 2023;57(4):751-758. <https://doi.org/10.1007/s43441-023-00526-0>
64. Carayon P, Wetterneck TB, Rivera-Rodriguez AJ, et al. Human factors systems approach to healthcare quality and patient safety.



- Appl Ergon. 2014;45(1):14-25. <https://doi.org/10.1016/j.apergo.2013.04.023>
65. McCoy LK. Look-alike, sound-alike drugs review: include look-alike packaging as an additional safety check. *Jt Comm J Qual Patient Saf.* 2005;31(1):47-53. [https://doi.org/10.1016/s1553-7250\(05\)31007-5](https://doi.org/10.1016/s1553-7250(05)31007-5)
66. Rattanarojsakul P, Thawesaengskulthai N. A medication safety model: a case study in Thai hospital. *Glob J Health Sci.* 2013;5(5):89. <https://doi.org/10.5539/gjhs.v5n5p89>
67. Sriboonruang P, Rattanamahattana M. Barcode Scanning Technology to Improve Pre-dispensing Errors. *Greater Mekong Subregion Medical Journal.* 2022;3(1):7-12.