Original Article

JHSMR Journal of Health Science and Medical Research

Effectiveness of The ME Online Program to Reduce Medication Errors among Primary Health Care Units in The City Areas of The Thai-Cambodian Border Provinces, Thailand

Sasithorn Pongprom, B.P.H.[1], Phannathat Tanthanapanyakorn, Ph.D.[1], Nonlapan Khantikulanon, M.Eng.[2], Sootthikarn Mungkhunthod, M.Sc.[1], Chaninan Praserttai, M.Sc.[2], Rungtiwa Fangchaiyaphum, B.P.H.[1], Warangkhana Siwilai, B.P.H.[1],Yossapatr Harnprasop, B.P.H.[1]

[1]Department of Public Health, Faculty of Public Health, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani 13180, Thailand.

[2]Department of Environmental Health, Faculty of Public Health, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani 13180, Thailand.

Received 31 May 2024 ● Revised 27 July 2024 ● Accepted 13 August 2024 ● Published online 24 February 2025

Abstract:

Objective: Medication errors are considered significant issues in public health operations. They are frequently encountered and continuously increasing, particularly in the border provinces of Thailand and Cambodia. This study was a quasi-experimental study conducted in order to examine the effectiveness of the ME online program for reducing medication errors in primary care units (PHCs) in the city areas of the Thai-Cambodian border.

Material and Methods: This study was conducted using a one-group pretest and posttest design by recruiting 36 participants responsible for drug administration through stratified sampling. They received the ME online program for 4 months. This program was designed to address knowledge, attitudes, and practices related to medication errors. The ME online platform was developed using Google Forms and Line official accounts to report and summarize medication errors. Data analysis involved descriptive statistics and paired t-tests.

Results: The findings indicate statistically significant increases in the mean scores of knowledge, attitudes, and practices related to medication errors compared to baseline and 4 months (p-value<0.001). Additionally, the rate of medication errors decreased from 7.4% to 4.5% compared to the baseline and 4 months after implementing the program. The

Contact: Phannathat Tanthanapanyakorn, Ph.D.
Department of Public Health, Faculty of Public Health, Valaya Alongkorn Rajabhat University under the Royal Patronage, Pathum Thani 13180, Thailand.
E-mail: Phannathat.tan@vru.ac.th

J Health Sci Med Res
doi: 10.31584/jhsmr.20251154
www.jhsmr.org

Category B medication error rate was reduced from 7.2% to 4.5%, and Category A from 0.2% to 0.0%. There was a statistically significant reduction in the medication error rates compared to baseline and at 4 months (p-value=0.038).
Conclusion: This ME online program effectively reduced medication errors and could also be integrated for collecting and reporting such events. Furthermore, it could be extended for an implementation in other areas of the Thai-Cambodian border provinces.

Keywords: city area, medication error, Thai-Cambodian border, primary healthcare units

Introduction

Medication errors pose a patient safety risk issue, with 2 proposed concepts regarding their occurrences: the personal concept posits that medication errors stem from individual mistakes, whereas, on the contrary, the systemic concept suggests that medication errors result more from environmental factors or systemic issues than human behavior[1]. Medication errors can occur due to various factors, such as medical personnel, individual patients, work environment, drugs, work practices, and information systems[2]. There are implications of medication errors on patients, medical personnel, and management[3]. Therefore, recording and reporting medication errors serve as fundamental data for guiding practices to prevent adverse drug events and reduce the severity of medication errors[4].

Furthermore, the World Health Organization reported that medication errors were frequently encountered in primary health care units (PHC), with a particularly high rate in some countries. For example, in the United Kingdom, medication errors accounted for 12.0% of all primary healthcare services, while in Sweden, the rate was 42.0%, and in Mexico, it was 58.0%[5]. A study by Assiri et al., who conducted a systematic review of the epidemiology of medication errors and risk factors for medication errors in PHCs, found that medication errors range from 2.0% to 94.0%[6]. Risk factors associated with medication errors include the number of medications prescribed, increasing patient age, comorbidities, and the level of family care . Therefore, management to reduce medication errors in primary healthcare facilities is crucial for enhancing patient safety[7].

The Primary Healthcare System Act of 2019 in Thailand provides the population with efficient primary healthcare services. The primary healthcare system serves as a mechanism for coordinating cooperation among the government sectors, local authorities, and the local communities[8]. Additionally, the Office of the Permanent Secretary of the Ministry of Public Health has outlined guidelines for the development of primary healthcare pharmacy systems with a focus on developing public knowledge regarding the rational use of medications and other health products[9]. This is to ensure the public's safety in their usage of medications and health products[10]. Therefore, primary healthcare pharmacy services align with addressing medication-related issues for comprehensive continuous healthcare[11].

Sakaeo Crown Prince Hospital oversees 21 PHCs, with chronic non-communicable disease patients being referred to receive services at nearby PHCs. The statistics of patients seeking services in PHCs for the year 2021 were 3,009 people, and for the year 2022 were 3,829 people[12]. From the data collection of medication errors reported by PHCs of Mueang district, it was found that there has been a continuous increase from the year 2021 to 2023. In 2021, there were a total of 626 medication error reports, comprising 623 incidents at severity level B and 3 incidents at severity level C. In 2022, there were 996 medication error reports, consisting of 994 incidents at severity level B and

2 incidents at severity level D. Moving on to 2023, there were 1,501 medication error reports, with 1,497 incidents at severity level B and 4 incidents at severity level D.

In conclusion, medication errors represent a significant issue in public health operations, often arising from individual mistakes[13]. Importantly, healthcare personnel should enhance their knowledge about medications, including dosage, frequency of use, contraindications of certain medications, and the principles of correct and appropriate practices[14]. This strategy can prevent medication errors, ensure patient safety, and improve treatment outcomes[15]. The previous method for reporting medication errors in the PHCs of Mueang district relied on paper-based medical records. This approach led to inaccuracies in recording information and delays in the timely reporting of medication errors. This program consisted of 2 components: improving healthcare personnel's knowledge, attitudes, and practices regarding medication errors, and implementing the ME online platform for documenting and reporting these errors. The study aimed to investigate the effectiveness of the ME online program by comparing medication error rates from PHCs in the city areas of the Thailand-Cambodia border before and after the experiment. It also aimed to compare the mean scores of knowledge, attitudes, and practice skills regarding medication errors among healthcare personnel from PHCs before and after the experiment. The results from this program will support a platform for reporting medication errors, maximizing patient benefits, prioritizing patient safety, and enhancing the quality of patient care.

Material and Methods

Study design and participants

This study was conducted using quasi-experimental research employing a one-group pretest-posttest design. Participants received the ME online program for 4 months. Data were obtained at 2 points: at the baseline, and subsequently after four-month evaluations. The study spanned from December 2023 to March 2024.

The population included 92 public health personnel from PHCs, spread across 21 locations in the urban areas of Sakaeo Province, located in Thailand's Thai-Cambodian border region. The researchers determined the sample size using G*Power, with an effect size of 0.66[17], an alpha value of 0.05, and a beta of 0.95. Based on this calculation, the initial sample comprised 32 participants. To reduce the likelihood of sample dropout, the researchers increased the sample size by an additional 15%, resulting in a final sample size of 36 individuals for this study.

Sampling, inclusion, and exclusion criteria

The participants were chosen randomly through stratified sampling. PHCs in Mueang Sakaeo District Health Office comprised 21 PHCs across 7 sub-districts as follows: 1.) 4 PHCs in Kok Pi Krong Sub-district 2.) 4 PHCs in Tha Yaek Sub-district 3.) 2 PHCs in Nong Bon Sub-district 4.) 2 PHCs in Tha Kasem Sub-district 5.) 3 PHCs in Sa Kwan Sub-district 6.) 3 PHCs in Sala Lamduan Sub-district, and 7.) 3 PHCs in Ban Kaeng Sub-district. Next, a representative from each sample group was selected by lottery. The number of samples from each sub-district was determined as depicted in Figure 1. PHCs with 4 or more health personnel had to select 2 representatives each to participate in the program. PHCs with fewer than 4 health personnel were required to select one representative from each PHC. The inclusion criteria comprised either health personnel responsible for pharmaceutical duties or those assigned to manage medication errors from PHCs for at least 1 year, including professional nurses and public health personnel affiliated with the Mueang Sakaeo District Health Office. They were male or female, aged 20 years or above. They were Thai health professionals skilled in communicating, responding, and writing in Thai. Healthcare personnel who had health issues during their participation in the program were excluded from the study.

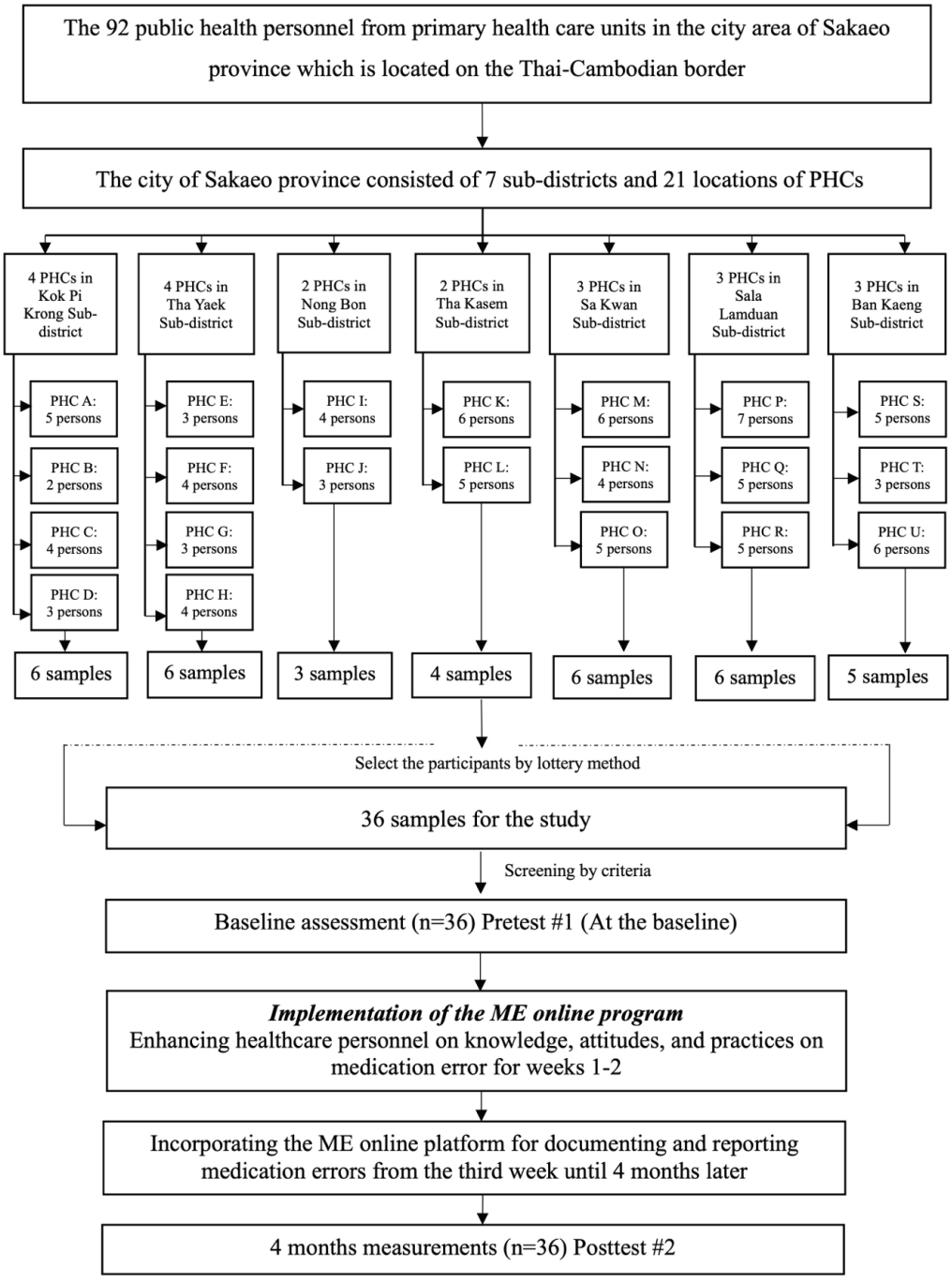

Figure 1 The flowchart of sampling and measurements timeline of the study

Intervention

Medication error (ME) is defined as any event in which healthcare personnel deviate from the standards or practices related to medication processes, and the consequences of such actions result in adverse drug events (ADEs) causing illness or various undesirable occurrences during medication use, which might also be caused by medications[18]. The severity of medication errors is classified into 9 levels, from A to I, according to the National Coordinating Council of Medication Error Reporting and Prevention (NCC MERP)[19]. It was commonly found in levels A to D and described as follows: Category A involves no actual error but potential for error. Category B involves an error with no impact on the patient. Category C involves an error that reaches the patient but does not cause harm. Category D involves an error that does not cause harm but requires increased monitoring.

Pre-implementation stage: the researchers developed the ME online program by applying the KAP model[20] to enhance healthcare personnel's knowledge, positively change their attitudes, and promote practices for the accuracy of medication error standards for recording and reporting medication errors. Moreover, this program applied the V-Shape model[21] to enhance accurate medication error practices by utilizing the 6 steps that consisted of cognitive, assessment, interrogation, decision, behavior change, and communicative skills on medication errors. Additionally, the program integrated Root Cause Analysis (RCA)[22] to explore the relationship between the problems and all the possible causes that may lead to medication errors in PHCs.

Afterward, community engagement was integrated into the ME online program to introduce essential content and ensure the program's continuity. Focus group discussions involved stakeholders, including hospital administrators, heads of PHCs, nurses, and public health providers from Sakaeo Province, Thailand, in designing the training session, emphasizing key details about medication errors, and establishing the ME online platform based on available resources. Ultimately, pivotal insights from the focus groups were incorporated into the ME online program, which was initially based on theoretical foundations. This initial program draft underwent a content validity assessment and received feedback from three experts. With a Content Validity Index (CVI) of 0.92, it demonstrated excellent content validity on the scale. Following this, the researchers refined the program details according to the suggestions and moved forward with program implementation.

After obtaining the name list of the participants, the researcher invited them to the Mueang Sakaeo District Health Office and conducted the first meeting before implementing the program. This meeting provided the objective of the study, intervention procedures, and measurements, and had the participants sign a consent form. Before the experiment, the researchers conducted pre-test measurements using a questionnaire. Moreover, the medication errors were recorded using the paper-based medical records of reporting medication errors from August to November 2023. This duration coincided with the period of utilizing the ME online program. Researchers collected medication error data from the Mueang Sakaeo District Health Office document, which compiles medication error reports from all PHCs.

Implementation stage: the ME online program comprised 2 distinct strategies: Firstly, enhancing healthcare personnel's knowledge, attitudes, and practices on medication error. These activities were conducted once a week for 3 hours during weeks 1-2 at the Mueang Sakaeo District Health Office. Week 1, titled "We Know & Aware": The researchers provided information to the participants on medication errors using PowerPoint presentations covering various topics such as medication dosage, precautions, and restrictions for certain medications that require caution during practice, the definition of medication errors, severity levels of medication errors, the Look Alike Sound Alike (LASA)

drugs, and guidelines for preventing medication errors. Following the presentations, there was a group discussion to exchange learning experiences. Additionally, motivational activities were conducted to emphasize the importance of documenting and reporting medication errors, with role models. Following this, RCA activities were carried out to identify errors in various processes such as medication ordering, recording medication data, medication preparation, and medication dispensing. Participants interacted and inquired about any work-related issues that had occurred, were divided into groups by sub-district, and presented the results of their analyses. Consequently, in Week 2, titled "We Skill": The researchers trained participants in the practical skills for documenting medication errors based on the V-shape model, and taught them how to use the ME online program to record and report medication errors. The target group received skills to use the ME online program in order to report medication errors on Google Drive correctly.

Secondly, incorporating the ME online platform for documenting and reporting medication errors in PHCs. The healthcare staff used the ME online platform from the third week until the end of 4 months to record and report medication errors. The ME Online platform was used to record and report medication errors through a Google Form created by the researchers and linked to the Line Official Account. The healthcare providers accessed this platform using the QR code to enter the ME online platform. Upon entering the program, the participants selected the month for reporting medication errors at each level. They specified the date of the medication error occurrence, and the name of the PHC, and selected the type of medication error. Furthermore, they provided a concise and accurate description of the medication error event, detailing the incident and specifying the causes resulting from work-related errors, and submitted the medication error report. The data were collected in a Google Drive database for future reporting. This allowed for real-time data reporting when medication errors occurred. Notifications were sent via Line Notify when medication error reports were submitted, starting from severity level B and above.

Post-implementation stage: After 4 months, the researchers conducted the assessment using the same measurements as the baseline, including a questionnaire on knowledge, attitudes, and practical skills regarding medication errors. Additionally, the ME online platform documented the medication errors after the 4 months, from December 2023 to March 2024.

Research instruments

The instruments were developed based on relevant theories and research related to medication errors[20,21,22]. The instrument consisted of 5 parts, as outlined below:

Part 1: The general interview form consisted of 7 questions both open-ended and closed-ended. The questions consisted of gender, age, income, education level, job position, responsibilities, and duration of employment.

Part 2: The medication error knowledge assessment form consisted of 20 multiple-choice questions. This instrument was created by reviewing diverse theories and relevant literature[13,14,20]. Each correct response earned 1 point, with a maximum score of 20. Score interpretation was classified into 3 levels using Bloom's criteria:[23] scores ranging from 0 to 11 demonstrated low knowledge, 12 to 15 demonstrated moderate knowledge, and 16 to 20 demonstrated high knowledge of medication errors.

Part 3: The measurement of attitudes toward medication errors included 15 questions. This tool was developed after studying the relevant literature[13,14]. The questions were structured on a Likert scale with 3 levels: agree, unsure, and disagree. They encompassed both positive and negative aspects, with a scoring system of 3, 2, and 1 for positive questions, and the reverse for negative ones. Interpretation of scores was categorized into 3 levels

following Best's criteria:[24] mean scores between 1.00 and 1.66 indicated low attitudes, mean scores from 1.67 to 2.33 indicated moderate attitudes, and mean scores from 2.34 to 3.00 indicated high attitudes toward medication errors.

Part 4: The evaluation form for practical skills in medication errors consisted of 15 questions, developed after studying the relevant literature[15]. It included inquiries regarding proficiency in medication management aimed at minimizing or averting medication errors, covering response, decision-making, and recording of medication errors. These questions were structured on a Likert scale with options: regular, occasional, and never, with scoring criteria of 3, 2, and 1. Scores were categorized into 3 levels based on Best's criteria:[24] scores from 1.00 to 1.66 indicated low practical skills, 1.67 to 2.33 indicated moderate practical skills, and 2.34 to 3.00 indicated high practical skills in medication error management.

Part 5: The medication error recording form, was a tool used to report errors that occur during medication-related tasks[19]. It utilizes the ME Online program and consists of 9 levels (A to I) that encompass various types of errors. These included errors in medication orders, copying of medication orders, recording of medication data, preparation of medication, verification of medication accuracy before dispensing, medication dispensing, and medication administration.

The tool's validity regarding peer assessment was ensured by consulting 3 experts in pharmacy, nursing, and public health, resulting in an Item Objective Congruence (IOC) score exceeding 0.95. A pilot study was conducted using a specific instrument for data collection to assess reliability. Thirty healthcare staff with characteristics similar to those of the participants participated in this pilot study. The reliability of the medication error knowledge assessment, evaluated using the Kuder-Richardson 21 (KR-21) method, was determined to be 0.90. Moreover, Cronbach's alpha coefficient exceeded 0.80 in the forms assessing attitudes toward medication errors, practical skills in medication error evaluation, and medication error recording.

Data collection

Following approval from the head of the Mueang Sakaeo District Health Office, the researchers requested that each PHC nominate healthcare providers to participate in the study, based on the inclusion criteria. During the initial meeting to implement the program, the researchers provided participants with information about the study's objectives, intervention procedures, and measurements. Participants were required to give their consent, which was documented through signed consent forms. Baseline measurements were obtained using a questionnaire assessing knowledge, attitudes, and practical skills regarding medication errors. Researchers collected medication error data from documents at the Mueang Sakaeo District Health Office, which consolidates medication error reports from all PHCs, covering the period from August to November 2023, utilizing the previous method. Subsequently, the same measurements were used to assess knowledge, attitudes, and practical skills related to medication errors after four months of program implementation. Medication errors were recorded over the four months from December 2023 to March 2024 using the ME online platform, with records stored in the Google Drive database.

Data analysis

Data analysis was conducted using the SPSS program, with a significance level set at 95.0%. Descriptive statistics were utilized to explore the general characteristics, aspects of medication errors, and other outcome variable descriptions. The Kolmogorov-Smirnov goodness-of-fit test was employed to assess the normality of outcome variables, indicating that all dependent variables followed a normal distribution (p-value>0.05). The paired t-test was used to examine differences in mean scores within groups

from the beginning of the program and after 4 months. A paired t-test was also conducted in order to compare the medication error rates at baseline and after 4 months.

Ethical considerations

The research study received approval from the Research Ethics Committee on Human Research at Valaya Alongkorn Rajabhat University under the Royal Patronange. The project was assigned identification numbers REC No. 0082/2023 and COA No. 0082/2023 and obtained certification on December 20, 2023. The study was carried out under the Declaration of Helsinki.

Results

General characteristics

The researchers trained 36 participants who took part in the study from the beginning of the program to the four-month assessments. Table 1 displays the general characteristics of the sample, indicating that the majority of healthcare providers were female (86.1%), aged between 20-39 years old (80.6%), earned a monthly income of less than 20,000 baht (36.1%), and held a Bachelor's degree (88.9%). Moreover, most worked as nurses (50.0%) or public health officers (50.0%). They were responsible for treatment (58.3%), and had been employed for more than 5 years (61.1%), followed by employed 1-5 years (38.9%).

Medication error rate at baseline and four months

The medication errors included prescribing errors (A), transcribing errors (B), pre-dispensing errors (C, D), dispensing errors (E, G, H), and administration errors (I). The rate of medication errors can be calculated by dividing the number of medication errors by the number of prescriptions and then multiplying by 100. Based on the ME recording before the experiment shown in Table 2, it was discovered that out of a total of 7,456 prescriptions, 554 medication errors were identified. This resulted in a medication error rate of 7.4%. The identified errors were categorized into levels A to D, with no errors detected at levels E to I. The majority of the errors fell under level B, accounting for the highest rate (7.2%), followed by level A (0.2%), level C (0.04%), and level D (0.01%). The sub-district of Nong Bon had the highest rate of medication errors (15.1%), followed by Tha Kasem (9.5%).

Table 1 The number and percentage of the variables divided by general characteristics (n=36)

Variables	n (%)
Age (years)	
20-39	29 (80.6)
40-59	7 (19.4)
Gender	
Female	31 (86.1)
Male	5 (13.9)
Income (baht/month)	
<20,000	13 (36.1)
20,000-25,000	11 (30.6)
25,001-30,000	5 (13.9)
>30,000	7 (19.4)
Education level	
Diploma/high vocational certificate	1 (2.8)
Bachelor's degree	32 (88.9)
Master's degree	3 (8.3)
Job position	
Nurse	18 (50.0)
Public health officer	18 (50.0)
Responsibilities	
Treatment	21 (58.3)
Prepare/dispense medication	8 (22.2)
Record or copy data	7 (19.4)
Duration of employment (years)	
1-5	14 (38.9)
>5	22 (61.1)

It was found from the data on medication errors after 4 months, shown in Table 3, that out of a total of 7,394 prescriptions, 335 medication errors were found, resulting in a medication error rate of 4.5%. These errors were only at level B, with no errors detected at levels A or C to I, accounting for a medication error rate of 4.5%. When examined by the sub-district, the Kok Pi Krong Sub-district

Table 2 The level of medication error rate in PHCs across each sub-district in the city areas of the Thai-Cambodian border region of Thailand at baseline (n=7)

Sub-districts	Number of prescriptions	Level of medication errors at baseline				Total of ME	
		A	B	C	D	n	%
1. Ban Kaeng	1,180	2	82	1	-	85	7.2
2. Sala Lamduan	1,375	3	81	-	-	84	6.1
3. Tha Kasem	588	-	55	-	1	56	9.5
4. Tha Yaek	1,299	8	88	-	-	96	7.4
5. Sa Kwan	1,443	-	88	-	-	88	6.1
6. Kok Pi Krong	1,313	3	101	2	-	106	8.1
7. Nong Bon	258	-	39	-	-	39	15.1
Total	7,456	16	534	3	1	554	
Proportion of ME		0.2	7.2	0.04	0.01		7.4

PHCs=primary healthcare units, ME=medication error

Table 3 The level of medication error rate in PHCs across each sub-district in the city areas of the Thai-Cambodian border region of Thailand after 4 months (n=7)

Sub-districts	Number of prescriptions	Level of medication errors after the four-months				Total	
		A	B	C	D	n	%
1. Ban Kaeng	1,165	-	51	-	-	51	4.4
2. Sala Lamduan	1,304	-	55	-	-	55	4.2
3. Tha Kasem	730	-	39	-	-	39	5.3
4. Tha Yaek	1,147	-	22	-	-	22	1.9
5. Sa Kwan	1,463	-	69	-	-	69	4.7
6. Kok Pi Krong	1,311	-	94	-	-	94	7.2
7. Nong Bon	274	-	5	-	-	5	1.8
Total	7,394	0	335	0	0	335	
Proportion of ME		0.0	4.5	0.0	0.0		4.5

PHCs=primary health care unit, ME=medication error

had the highest medication error rate (7.2%), followed by the Tha Kasem Sub-district (5.3%). Subsequently, Table 4 indicates that there was a statistically significant reduction in medication error rates compared to baseline and 4 months (p-value=0.038).

Effects of the ME online program within the group before and after

According to Table 5, there were statistically significant increases in knowledge, attitude, and practical skills related to medication errors between baseline and 4 months. The study found that knowledge of medication errors increased from 12.17±3.22 to 19.61±0.68 (p-value<0.001), attitude toward medication errors increased from 30.28±4.93 to 44.92±0.28 (p-value<0.001), and practical skills related to medication errors increased from 41.64±4.09 to 44.91±0.28 (p-value<0.001).

Table 4 Comparison of the mean medication error rates in PHCs across each sub-district at baseline and after 4 months (n=7)

Variables	Mean±S.D.	Mean Diff.	t	df	p-value
Medication error rate					
Baseline	8.50±3.14	-4.28	-2.643	6	0.038*
4 months	4.21±1.89				

paired t-tests were used to assess the data within each group, *At the 0.05 level of statistical significance, PHCs=primary health care unit, S.D.=standard deviation

Table 5 The average difference for all the parameters within the group at baseline and 4 months (n=36)

Variables	Mean± S.D.	Mean Diff.	t	df	p-value
Knowledge of medication errors					
Baseline	12.17±3.22	7.44	14.027	35	<0.001*
4 months	19.61±0.68				
Attitude toward medication errors					
Baseline	30.28±4.93	14.64	17.299	35	<0.001*
4 months	44.92±0.28				
Practical skills on medication errors					
Baseline	41.64±4.09	3.28	4.729	35	<0.001*
4 months	44.91±0.28				

paired t-tests were used to assess the data within each group *at the 0.05 level of statistical significance, S.D.=standard deviation

Discussion

After the four-month program compared to the baseline, there was a decrease in the medication error rate in PHCs compared to the baseline. Additionally, there was a significant improvement in knowledge, attitudes, and practical skills related to medication errors. The indicators of the NCC MERP[19] for medication errors specify that errors at levels B, C, and D must decrease, errors at levels E, F, G, and H should not exceed 20.0%, and errors at level I should not exceed 5.0%. The medication errors at each level have different descriptions, as follows: Category A: No error has occurred, but there is potential for an error. Category B: An error has occurred, but it did not reach the patient. Category C: An error has reached the patient but did not cause harm. Category D: An error occurred that did not cause harm but requires increased monitoring and surveillance. Category E: An error occurred that caused temporary harm and required treatment or additional intervention. Category F: An error occurred that necessitated an extension of the patient's treatment. Category G: An error occurred that caused permanent harm to the patient, such as disability. Category H: An error occurred that was life-threatening, such as anaphylactic shock or cardiac arrest[25].

According to medication error level A, these are minor medication errors that do not cause any harm or adverse effects to the patient. They are generally considered to be low-risk errors and are often easily detectable and correctable. Level A medication errors often occur due to

purchasing or procuring medications with similar forms or characteristics, which poses the risk of medication errors, and writing prescriptions that do not adhere to the appropriate practice standards[25]. The findings indicated a decrease in Level A errors after 4 months compared to baseline, showing that there were no Level A errors. It can be stated that the program likely provided targeted training and educational resources that helped staff better understand and manage level A errors, leading to a decrease in such errors. The absence of level A errors in some settings after using the ME online platform suggests that the platform had a positive impact on reducing minor errors.

According to the findings, medication error rates at levels B, C, and D decreased compared to the baseline and the four-month mark. Moreover, the medication error rates at levels E, F, G, H, and I were not observed at baseline or after 4 months of implementation, which satisfied the indicator criteria[19]. Importantly, achieving effectiveness is a gradual process that ultimately leads to success. The primary goal is to expedite the reporting of medication errors and ensure compliance with medication error reporting standards, resulting in a reduction of medication errors. It was noticed that the use of the ME online program led to a decrease in medication error rates[25]. Additionally, this finding after 4 months indicated that the errors were only at Level B. This demonstrates a reduction in the overall medication error rate, suggesting that the program has likely been effective in decreasing errors. Level B medication errors are commonly found in PHCs and are indicative of transcription errors, which involve inaccuracies in copying medication orders from the original prescription written by the prescriber. Due to the limited number of health professionals directly involved with medication in PHCs, other health staff have had to assume these responsibilities. The results of this study align with the findings of Wadudom, who demonstrated that the implementation of a pre-dispensing and pharmaceutical service system resulted in a decrease in the pre-dispensing error rate from 8.42 to 5.52 and a reduction in the dispensing error rate from 4.62 to 2.96. It is worth noting that no category E to I errors were reported[26]. The findings of the present research are similar to the study of Chanatepaporn who conducted prescribing error programs for reporting in hospitals and demonstrated that the majority of identified prescribing errors were categorized as level B (99.4%). Among in-patient prescriptions, there were 693 prescribing errors (0.63 per 1,000 prescriptions); a decrease was observed after implementing the program[27]. Moreover, the results of this study are consistent with Rattanajutanon and Saensom, who found that after the implementation of the program, medication errors were 2.13 times lower in the experimental group compared to the control group. Therefore, this program could help reduce medication errors[28].

Medication errors in primary care settings compared to hospitals: It has been shown that primary care settings typically deal with a wide range of conditions but may address fewer complex cases than hospitals. While hospitals generally have more intensive and complex medication management due to the nature of acute and specialized care, error rates may be higher in hospitals because of the complexity and volume of medications administered. However, considering these factors, a 7.4% medication error rate in a primary care setting is not easily labeled as large or small without additional context. It is crucial to compare this rate to benchmarks or average rates in similar primary care settings and to take into account the specific circumstances surrounding the reported errors. Moreover, evaluating the impact of these errors, including their severity and outcomes, allows for a more meaningful comparison with hospital settings. This ME online platform was properly developed for PHCs; however, it cannot be generalized for adoption in a hospital context. While the core functionalities of the platform may be transferable, the outcomes can differ due

to the distinct operational environments and requirements of primary healthcare units and hospitals.

The outcome of the study clarified that firstly, medication errors occur when healthcare providers deviate from standard or recommended medication procedures, potentially leading to adverse outcomes related to medication usage. Improving healthcare performance and utilizing the ME online platform can prevent medication errors. The program offers extensive education and training to healthcare professionals regarding the best practices for medication management. By improving their knowledge, promoting a positive attitude towards medication errors, and enhancing practice skills related to medication errors, healthcare professionals are better equipped to prevent errors[29]. A similar study by Farzi et al. indicated that after implementing a blended learning program, the average number of medication administration errors in the medical wards significantly decreased compared to before the intervention[30]. Moreover, this was consistent with the KAP model illustrating the relationship between knowledge, attitude, and practices[20]. Enhancing understanding and knowledge, and cultivating positive health-related attitudes, can effectively influence the practice of medication error reduction in PHC[26].

Secondly, emphasizing a positive attitude toward medication errors shows that motivational activities highlighting the importance of documenting and reporting these errors can enhance awareness of medication safety. Elements of motivation in the program, such as success stories, real-world case studies, and the potential impact of medication errors on patient safety, may have further encouraged providers to cultivate a more proactive attitude toward error prevention. In addition, RCA activities provide valuable insights into how and why errors occur. This improved mindset helps staff recognize potential risks, allowing them to adopt better practices and foster a proactive approach to error prevention. During the RCA process, staff contributions to identifying problems and solutions are acknowledged and appreciated. This fosters a positive attitude toward the ongoing improvement of medication practices[22].

The summarized data from the RCA activity demonstrated that the primary causes of medication errors were as follows: 1) Insufficient knowledge about medications, dosage, or procedures, which can lead to errors. 2) Flaws or inconsistencies in medication administration procedures or protocols. 3) High workload or inadequate staffing, which can contribute to fatigue and lead to errors. Secondary causes of medication errors, which contribute to or exacerbate the primary causes, were identified as 1) Lack of thorough training on new systems, protocols, or medications. 2) Inadequate documentation practices, leading to incomplete or inaccurate information regarding medication orders.

Thirdly, enhancing practical skills related to medication errors demonstrated that this program employs the V-shape model to develop these skills by training individuals in six key steps. These steps include: 1) cognitive skills to improve understanding of the guidelines for practicing medication error principles, 2) assessment skills for identifying and searching relevant sources of information, 3) interrogation skills to effectively communicate through speaking, reading, and writing in order to persuade others to understand and accept information, 4) decision-making skills needed to evaluate various options and choose the appropriate course of action, 5) behavior-change skills to set and achieve goals, plan and implement corrective actions, and review practices aimed at reducing medication errors, and 6) teaching skills necessary to educate communities and society about medication errors. The V-shape model offers a structured approach that systematically guides participants from theoretical learning to practical application and evaluation. This structured process ensures comprehensive understanding and effective skill development. By incorporating practical exercises and role-

playing, the model reinforces theoretical knowledge while enhancing practical skills. This hands-on experience is crucial for improving competency in managing medication errors[31].

Fourthly, the ME online platform using Google Forms promotes the adoption of standardized procedures and protocols for medication management across PHCs. Additionally, this platform encourages healthcare personnel to report medication errors promptly and accurately. The program facilitates continuous improvement in medication safety practices by collecting data on mistakes, analyzing root causes, and implementing corrective actions. The ME online platform provides healthcare personnel with a checklist and links to official line account tools that help them follow best practices and prevent common errors[32]. Primary healthcare settings can significantly reduce medication errors and improve patient safety by utilizing the ME online program.

Once the program is completed, it is recommended to conduct training sessions every 6 months to reskill all healthcare personnel[33]. Information technology tools such as the ME online program should be utilized to establish a medication error reporting and recording system in order to prevent medication errors that occur with patients[34]. Additionally, the sustainability of knowledge over time is crucial to maintaining a low medication error rate. Without ongoing reinforcement, knowledge retention can decrease over time. Therefore, the District Health Office should offer refresher courses or updates to help reinforce knowledge and ensure that participants stay current with best practices. Additionally, it should regularly monitor medication error rates and evaluate the effectiveness of the training program, using this data to make the necessary adjustments. Furthermore, fostering a culture that emphasizes the importance of continuous learning and adherence to safety protocols is essential. Due to the shortage of pharmacists in Primary Health Care Units (PHC), other healthcare professionals have to take on medication management tasks[35,36]. Hence, administrators should clearly define the goals and methods for promoting safety and preventing errors. Clear roles and responsibilities should be established for each staff member, and teamwork should be promoted among interdisciplinary professionals.

Implications for future developments: Cost-effectiveness assessments of medication management for PHCs should be conducted. Importantly, the program's long-term impact should be evaluated over 1-3 years to ensure sustainable outcome measurements and identify any necessary system changes related to medication management. To facilitate this process, the development of a mobile application for collecting data on medication errors and designing a medication discrepancy monitoring system for a larger population are suggested. It is important to note that this research has certain limitations. Firstly, the study was carried out in PHCs, located in urban areas of the Thai-Cambodian border. Therefore, the findings cannot be easily applied to other rural areas. Secondly, the use of a small sample size may have created some bias, making it difficult to generalize the results to the larger population. Thirdly, this program requires software maintenance and a reliable internet connection to function properly. To maintain the sustainability of the ME online program, the software should be designed to scale with the increasing number of users or expand content requirements. Stable and reliable internet access is crucial for the smooth operation of online programs. Organizations should ensure that their internet infrastructure is robust and capable of handling the program's demands.

Conclusion

The online ME program has been proven to effectively reduce medication error rates, establish patient safety, and ultimately lead to an improved quality of patient care. The obtained outcomes can be utilized to implement

various aspects: The ME online platform can be integrated by healthcare providers for reporting and recording medication errors, effectively reducing medication errors. Moreover, public health administrators and policymakers can utilize data from the ME online program to gather basic medication-related information. This information can serve as a guideline for managing risks that may arise from errors in the operational procedures of PHCs.

Acknowledgement

The authors express their gratitude to the head of the Sakaeo District Health Office for granting permission for the data collection and implementation of the ME online program. Furthermore, we extend our appreciation to the healthcare providers in the PHCs of the Thai-Cambodian border region of Thailand for willingly and cooperatively participating in the study.

Conflict of interest

The authors declared no potential conflicts of interest regarding this article's research, authorship, and/or publication.

References

1. Farzi S, Irajpour A, Saghaei M, Ravaghi H. Causes of medication errors in intensive care units from the perspective of healthcare professionals. J Res Pharm Pract 2017;6:158-65.
2. Berdot S, Roudot M, Schramm C, Katsahian S, Durieux P, Sabatier B. Interventions to reduce nurses' medication administration errors in inpatient settings: a systematic review and meta-analysis. Int J Nurs Stud 2016;53:342-50.
3. Moradi Moghaddam O, Keshtkar A, Sedighi M, Amanollahi A, Aghakhani K, Niakan Lahiji M. Investigating causes of medical errors in intensive care units in Iran: a cross-sectional study. Med J Islam Repub Iran 2023;37:79.
4. Alzoubi MM, Al-Mahasneh A, Al-Mugheed K, Al Barmawi M, Alsenany SA, Farghaly Abdelaliem SM. Medication administration error perceptions among critical care nurses: a cross-sectional, descriptive study. J Multidiscip Healthc 2023;16:1503-12.
5. World Health Organization (WHO). Medication without harm [homepage on the Internet]. Geneva: WHO; 2022 [cited 2023 Sep 22]. Available from:https://www.who.int/initiatives/medication-without-harm.
6. Assiri GA, Shebl NA, Mahmoud MA, Aloudah N, Grant E, Aljadhey H, et al. What is the epidemiology of medication errors, error-related adverse events, and risk factors for errors in adults managed in community care contexts: a systematic review of the international literature. BMJ Open 2018;8:e019101.
7. Khalil H, Lee S. The implementation of a successful medication safety program in primary care. J Eval Clin Pract 2018;24:403-7.
8. Khrueawang K. Medication error. Public Health Policy Laws J 2018;4:251-65.
9. Rattanadejsakul J, Rattanadejsakul P. Medication errors and their benefits in the pharmaceutical management system [homepage on Internet]. Bangkok: Pharmacy Council; 2017 [cited 2023 Jul 1]. Available from: http://ccpe.pharmacycouncil.org/showfile.php?file.
10. Escrivá Gracia J, Brage Serrano R, Fernández Garrido J. Medication errors and drug knowledge gaps among critical-care nurses: a mixed multi-method study. BMC Health Serv Res 2019;19:640. doi: 10.1186/s12913-019-4481-7.
11. Bifftu BB, Mekonnen BY. The magnitude of medication administration errors among nurses in Ethiopia: a systematic review and meta-analysis. J Caring Sci 2020;9:1-8.
12. Sa Kaeo Provincial Public Health Office. Statistical of the rate of medication errors in the primary health care units between 2021-2023. Sa Kaeo Province, Thailand: Sa Kaeo Provincial Public Health Office; 2023.
13. Brabcová I, Hajduchová H, Tóthová V, Chloubová I, Červený M, Prokešová R, et al. Reasons for medication administration errors, barriers to reporting them and the number of reported medication administration errors from the perspective of nurses: a cross-sectional survey. Nurse Educ Pract 2023;70:103642.
14. Alghamdi AA, Keers RN, Sutherland A, Ashcroft DM. Prevalence and nature of medication errors and preventable adverse drug events in pediatric and neonatal intensive care settings: a systematic review. Drug Saf 2019;42:1423-36.
15. Irajpour A, Farzi S, Saghaei M, Ravaghi H. Effect of interprofessional education of medication safety program on the medication error of physicians and nurses in the intensive care units. J Educ Health Promot 2019;8:196.

16. Sakaeo District Health Office. Number of medical and public health personnel in the primary health care units. Sa Kaeo Province, Thailand. 2023.
17. Manias E, Cranswick N, Newall F, Rosenfeld E, Weiner C, Williams A, et al. Medication error trends and effects of person-related, environment-related, and communication-related factors on medication errors in a pediatric hospital. J Paediatr Child Health 2019;55:320-6.
18. Oweidat I, Al-Mugheed K, Alsenany SA, Abdelaliem SMF, Alzoubi MM. Awareness of reporting practices and barriers to incident reporting among nurses. BMC Nurs 2023;22:231.
19. National Coordinating Council of Medication Error Reporting and Prevention (NCC MERP). Types of medication errors [homepage on the Internet]. Maryland: NCC MERP; 2001 [cited 2023 Nov 17]. Available from: https://www.nccmerp.org/types-medication-errors.
20. Schwartz NE. Nutritional knowledge, attitudes, and practices of high school graduates. J Am Diet Assoc 1975;66:28-31.
21. Department of Health, Ministry of Public Health, Thailand. Concepts and principles of the health literacy organization [homepage on the Internet]. Nonthaburi: MOPH; 2018 [cited 2023 Oct 10]. Available from: https://mwi.anamai.moph.go.th/
22. Singh G, Patel RH, Boster J. Root cause analysis and medical error prevention. StatPearls. Treasure Island (FL): StatPearls Publishing; 2024.
23. Bloom BS. Taxonomy of educational objectives, handbook: the cognitive domain. New York: David McKay; 1956.
24. Best JW. Research in Education. New Jersey: Prentice Hall Inc; 1977.
25. Ministry of Public Health of Thailand. Family pharmacists ' guidelines for developing primary care pharmacy systems in fiscal year 2022-2024 [homepage on the Internet]. Nonthaburi: MOPH; 2022 [cited 2023 Oct 10]. Available from:https://dmsic.moph.go.th/index/detail/8895.
26. Wadudom J. Development of a pre-dispensing system in inpatient pharmacy services to reduce medication error. Thai J Clin Pharm 2020;26:1-15.
27. Chanatepaporn P. Development of a prescribing error program for reporting in Srinagarind Hospital. Srinagarind Med J 2019;34: 261-70.
28. Rattanajutanon S, Saensom D. Effects of medication error prevention program on the incidence of medication administration errors of registered nurses in an intensive care unit. HCU J 2022;26:183-95.
29. Chen KL, Hunag CF, Sheng WH, Chen YK, Wang CC, Shen LJ. Impact of integrated medication management program on medication errors in a medical center: an interrupted time series study. BMC Health Serv Res 2022;22:796.
30. Farzi K, Mohammadipour F, Toulabi T, Heidarizadeh K, Heydari F. The effect of blended learning on the rate of medication administration errors of nurses in medical wards. Iran J Nurs Midwifery Res 2020;25:527-32.
31. Eisenbach N, Shqara RA, Sela E, Hana RY, Gruber M. The effect of an interventional program on the occurrence of medication errors in children. Int J Pediatr Otorhinolaryngol 2020;138:110373.
32. Manias E, Kusljic S, Wu A. Interventions to reduce medication errors in adult medical and surgical settings: a systematic review. Ther Adv Drug Saf 2020;11:2042098620968309.
33. Tahseen H, Brown J. Effects of tailored quality improvement program for effective medication management in high dependency in-patient psychiatry rehabilitation unit. BJPsych Open 2021;7:S53-4.
34. Di Muzio M, De Vito C, Tartaglini D, Villari P. Knowledge, behaviors, training and attitudes of nurses during preparation and administration of intravenous medications in intensive care units (ICU): a multicenter Italian study. Appl Nurs Res 2017;38:129-33.
35. Mutair AA, Alhumaid S, Shamsan A, Zaidi ARZ, Mohaini MA, Al Mutairi A, et al. The effective strategies to avoid medication errors and improve reporting systems. Medicines 2021;8:46.
36. Damin Abukhalil A, Amer NM, Musallam LY, Al-Shami N. Medication error awareness among health care providers in Palestine: a questionnaire-based cross-sectional observational study. Saudi Pharm J 2022;30:470-7.