



การพัฒนาและประเมินผลการใช้รูปแบบการบริหารยาแบบมีส่วนร่วมของพยาบาลวิชาชีพ เพื่อป้องกันการเกิดความคลาดเคลื่อนทางยา ในหออภิบาลผู้ป่วยเด็ก

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The Development and Evaluation of a Participatory Medication Administration Model for Registered Nurses to Prevent Medication Errors in the Pediatric Intensive Care Unit at Songklanagarind Hospital

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บทคัดย่อขยาย

ความเป็นมาและวัตถุประสงค์ ความคลาดเคลื่อนทางยาเป็นปัญหาทางการแพทย์ที่สำคัญ โดยเฉพาะในผู้ป่วยเด็กซึ่งมีความเสี่ยงสูงกว่าผู้ใหญ่หลายเท่า จากสาเหตุที่เกี่ยวข้องกับการสั่งยา การคำนวณยา และการบริหารยาที่ผิดพลาด แม้หน่วยงานจะมีมาตรการด้านความปลอดภัยในการใช้ยาอยู่แล้ว แต่ยังคงพบความคลาดเคลื่อนทางยาอย่างต่อเนื่อง พยาบาลจึงมีบทบาทสำคัญในการป้องกันความผิดพลาดดังกล่าว ผ่านการมีส่วนร่วมในการพัฒนาแนวทางปฏิบัติ การวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนารูปแบบการบริหารยาแบบมีส่วนร่วมของพยาบาลวิชาชีพในหออภิบาลผู้ป่วยเด็ก โรงพยาบาลสงขลานครินทร์ และศึกษาผลของการใช้รูปแบบต่อการปฏิบัติ ความรู้ ความพึงพอใจ และอุบัติการณ์ความคลาดเคลื่อนทางยา รวมถึงเปรียบเทียบระดับความรู้และความพึงพอใจก่อนและหลังการใช้รูปแบบ

วิธีการวิจัย การวิจัยครั้งนี้เป็นการวิจัยและพัฒนา (Research and Development) ดำเนินการ 4 ขั้นตอน ได้แก่ 1) การระบุปัญหา 2) การสืบค้นหลักฐานและการสร้างแนวปฏิบัติ 3) การนำแนวปฏิบัติไปใช้จริง และ 4) การประเมินผลการปฏิบัติ กลุ่มตัวอย่าง คือ พยาบาลวิชาชีพ จำนวน 33 ราย ที่ปฏิบัติงานในหออภิบาลผู้ป่วยเด็ก โรงพยาบาลสงขลานครินทร์ เครื่องมือที่ใช้ในการเก็บข้อมูลประกอบด้วย แบบสอบถามข้อมูลส่วนบุคคล แบบสังเกตการปฏิบัติ แบบทดสอบความรู้ แบบประเมิน

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ความพึงพอใจ และแบบบันทึกอุบัติการณ์ความคลาดเคลื่อนทางยา วิเคราะห์ข้อมูลโดยใช้สถิติบรรยาย แสดงค่าความถี่ ร้อยละ ค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐาน เปรียบเทียบค่าเฉลี่ยคะแนนความรู้และความพึงพอใจด้วยสถิติ Paired t-test กำหนดระดับนัยสำคัญทางสถิติที่ .01

ผลการวิจัย พบว่า หลังการใช้รูปแบบการบริหารยาแบบมีส่วนร่วม พยาบาลมีคะแนนความรู้และความพึงพอใจเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติที่ระดับ .01 ทั้งในภาพรวมและรายด้าน ได้แก่ ด้านความรู้ทั่วไปเกี่ยวกับยา ด้านการประเมินก่อนให้ยา และด้านการบริหารยาแบบมีส่วนร่วม ขณะเดียวกัน ร้อยละของพยาบาลที่ปฏิบัติตามมาตรฐานการบริหารยาของหน่วยงานเพิ่มขึ้นในเกือบทุกรายการ และจำนวนอุบัติการณ์ความคลาดเคลื่อนในการบริหารยาที่รายงานลดลงอย่างเห็นได้ชัด

สรุปและข้อเสนอแนะ การมีส่วนร่วมของพยาบาลในการคิด ตัดสินใจ และปฏิบัติงานร่วมกัน ในรูปแบบการบริหารยาที่พัฒนาขึ้น ช่วยเพิ่มความรู้และการปฏิบัติตามมาตรฐานการบริหารยาของพยาบาล พยาบาลมีความพึงพอใจต่อรูปแบบดังกล่าวในระดับสูง โดยเฉพาะด้านความสามารถนำไปใช้ได้จริงในการปฏิบัติงาน และพบว่าอุบัติการณ์ความคลาดเคลื่อนทางยาลดลงภายหลังการใช้รูปแบบ ผลการศึกษาสนับสนุนว่าความร่วมมือแบบสหวิชาชีพ การรับผิดชอบร่วมกัน และการเรียนรู้อย่างต่อเนื่อง อาจช่วยส่งเสริมความปลอดภัยด้านยาในหออภิบาลผู้ป่วยเด็กได้ อย่างไรก็ตาม เนื่องจากการศึกษาในหน่วยงานเดียวโดยไม่มีกลุ่มเปรียบเทียบ การนำรูปแบบนี้ไปประยุกต์ใช้ในหน่วยงานอื่นควรพิจารณาบริบทของแต่ละหน่วยงานประกอบด้วย

คำสำคัญ: รูปแบบการบริหารยาแบบมีส่วนร่วม, ความคลาดเคลื่อนทางยา, หออภิบาลผู้ป่วยเด็ก

Extended Abstract

Background and Objectives Medication error is a critical patient-safety issue, and pediatric patients face significantly higher risk than adults from prescription, dosage-calculation, and administration errors. Despite existing medication safety measures, errors continued to occur, highlighting a gap that active nurse participation may help address. This research aimed to develop a participatory medication administration model involving professional nurses in the Pediatric Intensive Care Unit (PICU) of Songklanagarind Hospital and examine its effects on practice, knowledge, satisfaction, and medication error incidence, including pre-post comparisons of knowledge and satisfaction.

Methods This R&D study was conducted in four phases: 1) problem identification, 2) evidence retrieval and development of the practice guideline, 3) implementation of the guideline in



clinical practice, and 4) evaluation of its implementation outcomes, with 33 registered nurses in the PICU. Data were collected using five researcher-developed tools, a demographic questionnaire, observation checklist, knowledge test, satisfaction survey, and a medication error reporting record form. Data were analyzed using descriptive statistics, including frequency, percentage, mean, and standard deviation. Mean differences in knowledge and satisfaction scores were analyzed using the paired t-test, with the statistical significance level set at .01

Results showed that after implementing the participatory model, nurses' knowledge and satisfaction increased significantly ($p < .01$), both overall and across domains, including general medication knowledge, pre-administration assessment, and medication administration practices. Compliance with the unit's medication administration standards also increased across most practice items, and a reduction was observed in the number of reported medication errors after implementation.

Conclusions and Recommendations This study suggests that a participatory approach emphasizing shared thinking, decision – making, and practice may enhance nurses' knowledge and compliance with medication administration standards and may be accompanied by a reduction in the number of reported medication errors. Given the single-setting, uncontrolled design, further adaptation and evaluation of the Model in other clinical settings are recommended before wider implementation.

Keywords: Participatory medication administration, Medication errors, Pediatric intensive care unit

Introduction

Medication errors and adverse drug events are among the major problems encountered in the medication-use process (Khunkaewla, 2024). In the United Kingdom, approximately 850,000 adverse drug events are reported annually (World Health Organization [WHO], 2016). In a hospital in Lao PDR, medication errors resulted in patient harm requiring treatment in 37.36 % of cases and required monitoring in 32.97 % of cases (Saithala & Jampamool, 2021). The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) further reported that 60 % of adverse clinical risks involved nurses, particularly during medication administration (Chang et al., 2005). Medication administration is the final step before medications reach patients and encompasses medication preparation, drug



mixing, administration, monitoring for adverse reactions, and documentation (Ethongchai et al. , 2020).

Medication errors are more common among pediatric than adult patients; pediatric patients are approximately three times more likely to suffer life-threatening harm from such errors (Pinrat et al., 2018), a vulnerability driven by weight-based dose calculations, off-label formulations, and limited physiological reserve to compensate for dosing mistakes. Incorrect dosage prescription and incomplete medication orders are the most common prescribing errors, with the highest incidence reported among respiratory medications (Ingcharoensunthorn et al., 2022); in pediatric intensive care units, errors are commonly attributed to unclear communication, absent independent verification, interruptions during administration, and non-adherence to guidelines. A quiet working environment, double-checking systems, and interprofessional collaboration have been shown to reduce such errors (Homniam & Ratchukoon, 2016), as have technologies such as computerized physician order entry and barcode-assisted administration, which can cut wrong – medication errors by up to 76 % (Pothisuntorn, 2019); evidence-based guidelines for high-alert medications with active nurse participation likewise improve nurses' knowledge and satisfaction (Weerakitti et al., 2013).

The Pediatric Intensive Care Unit (PICU) at Songklanagarind Hospital cares for critically ill pediatric patients aged 1 month to 18 years, as well as neonates requiring cardiac surgery or mechanical cardiopulmonary support. Approximately 541 patients are admitted annually, with approximately 60,000 medication record entries documented each year, representing an average of 111 medication record entries per patient. The hospital's incident reporting system identified 28 reported medication error incidents during 2019 – 2020, including some case resulting in temporary harm and death (reported as case counts rather than a comparable rate, since reporting periods and denominators differed across years), attributed to human factors, prescribing errors, and the complexity of the medication-use process. Despite corrective measures, including standardized medication doses and concentrations, 13 medication error cases were still reported in 2021. Barcode-assisted medication administration and a dedicated clinical pharmacist were subsequently introduced in 2022 and 2023, respectively; however, 14 and 12 medication error cases were reported in those years, respectively (Songklanagarind Hospital, 2023). The reported consequences included new health complications, prolonged hospitalization, and, in severe cases, death (Doommai et al., 2021).



Despite these corrective measures, medication errors persisted, suggesting that structural and technological safeguards alone are insufficient without active engagement from frontline nurses. The researcher, who was a staff nurse and medication safety champion in the PICU, therefore developed a participatory medication administration model for registered nurses (hereafter, “the Model”), emphasizing shared thinking, decision-making, and practice rather than reliance on a static guideline. The Model aimed to strengthen nurses' knowledge and confidence in medication safety and promote continuous improvement in the quality of nursing care.

Objectives

1. To develop a participatory medication administration model for registered nurses to prevent medication errors in the Pediatric Intensive Care Unit (PICU), Songklanagarind Hospital.
2. To evaluate the effects of the participatory medication administration model on registered nurses' medication administration practices and the number of reported medication errors.
3. To compare nurses' knowledge before and after the implementation of the participatory medication administration model.
4. To compare nurses' satisfaction before and after the implementation of the participatory medication administration model.

Conceptual Framework

This research and development (R&D) study aimed to develop a participatory medication administration model for registered nurses to prevent medication errors in the Pediatric Intensive Care Unit (PICU). It integrated two frameworks: the CANP Evidence-Based Practice Model (Soukup, 2000), guiding the overall process from problem identification to evaluation, and Weerakitti et al. (2013) four-phase framework (problem identification, evidence retrieval and development of the practice guideline, implementation of the guideline in clinical practice, and evaluation of its implementation outcomes), which shaped the model's clinical content. Together, these frameworks aimed to improve nurses' practices, knowledge, and satisfaction while reducing medication errors. The study comprised four phases (Figure 1):



Phase 1: Problem identification.

This phase involved identifying and tracing medication error incidents previously reported in the unit to analyze existing problems and barriers. A multidisciplinary development team comprising 11 members was established, including faculty physicians, medical interns, pharmacists, nurse medication safety champions, and advanced practice nurses.

Phase 2: Evidence retrieval and development of the practice guideline.

The researcher and the development team conducted a systematic search for evidence published between 2012 and 2022 using the PICO framework. The quality of the retrieved evidence was critically appraised according to the Joanna Briggs Institute (JBI) methodology. The draft practice guideline was subsequently evaluated using the Delphi technique with 11 experts over three rounds to achieve expert consensus, with a predefined consensus threshold of more than 75 % agreement. Following completion of the three Delphi rounds, 21 of the 27 items (77.78 %) met the predefined consensus criterion of more than 75 % agreement and were incorporated into the final version of the clinical practice guideline.

Phase 3: Implementation of the guideline in clinical practice

3.1 Pilot implementation and observation: The developed Model was initially piloted over a one-week period to observe nurses' medication administration practices and identify any issues requiring refinement.

3.2 Full implementation: Following the pilot phase and necessary refinements, the Model was implemented in routine clinical practice for six months.

Phase 4: Evaluation of implementation outcomes

At the end of the six-month implementation period, nurses' knowledge and satisfaction were evaluated, and the number of reported medication errors was compared between the six-month periods before and after implementation.

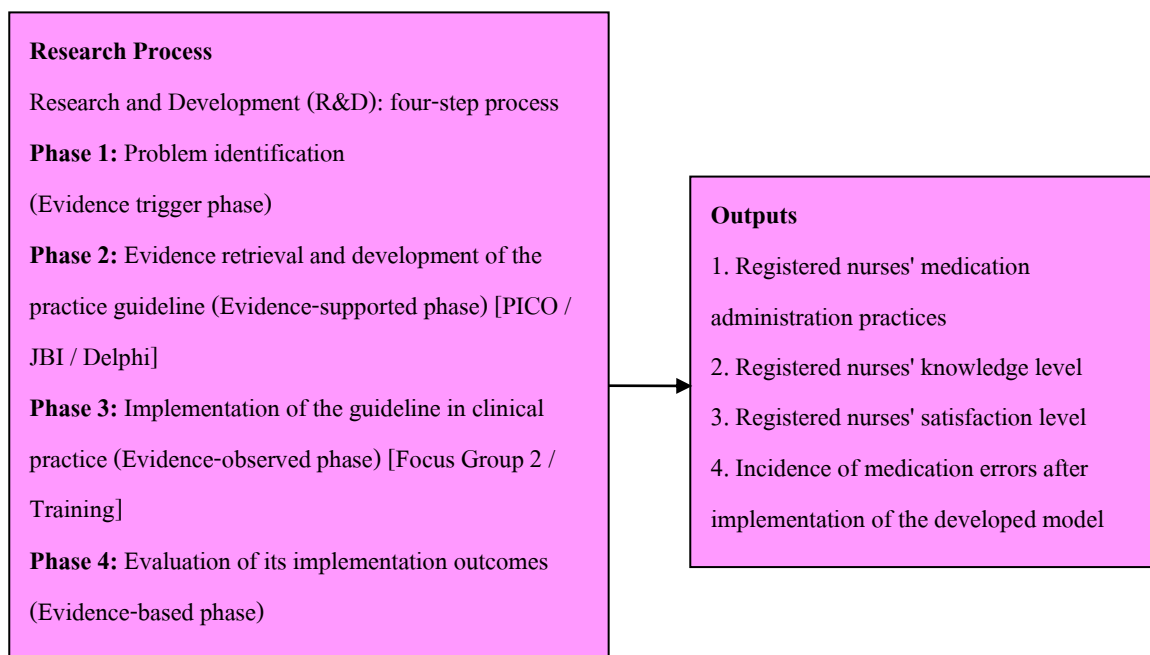


Figure 1 Conceptual framework

Methods

Design

This study employed a research and development (R&D) design.

Participants and Setting

The study population comprised all registered nurses at all professional levels working in the Pediatric Intensive Care Unit (PICU), Songklanagarind Hospital; since all eligible nurses meeting the criteria below were enrolled, rather than a subset drawn from a larger population, this is more accurately described as total population sampling. Inclusion criteria were: 1) registered nurses at all professional levels working in the PICU; 2) at least six months of work experience in the unit, including a formal performance evaluation by the Nursing Service Department; and 3) active employment during the study period following Ethics Committee (EC) approval. Exclusion criteria were: 1) serving as the unit's head nurse; and 2) resignation, educational leave, or maternity leave during data collection; nurses who did not provide informed consent were also not enrolled. A minimum sample size was estimated a priori using power analysis ($\alpha = .05$, power = .80, effect size = .45, derived from Wongtawee et al. (2020) yielding a required minimum of 33; all 33 eligible nurses were enrolled, consistent with total population sampling.



Research Instruments and Measures

The research instruments were classified into two categories: 1) instruments used for the research intervention and 2) instruments used for data collection.

1. Instruments Used for the Research Intervention

1.1 Medication Administration Manual. Developed by the researcher and multidisciplinary development team from hospital medication records, institutional protocols, and appraised evidence, the Manual (also referred to as the unit-specific medication handbook) provided guidelines on medication prescribing principles, order verification, standard dosages and concentrations of commonly used PICU medications, and dosage calculation formulas; it was distributed to all participating nurses during implementation.

1.2 Participatory Medication Administration Model. The Model was developed from the best available evidence and the four-phase framework proposed by Weerakitti et al. (2013), through collaborative development with the multidisciplinary team and participating nurses, who took part in group discussions, pilot feedback, and workflow refinement. Development also produced several practice agreements: multidisciplinary bedside rounds addressing medication management, standardized medication preparation for all patients, a ban on mobile-phone use during preparation and administration, and an additional three-way stopcock for inotropic infusions to support the double-syringe technique and prevent hemodynamic instability during line changes. The Model's three clinical phases were: pre-administration (medication history, order verification and transcription, pharmacist confirmation, dosage calculation, and preparation); administration (patient/family education, a safe administration environment, correct procedure, and documentation); and post-administration (monitoring therapeutic outcomes and adverse drug reactions).

2. Instruments Used for Data Collection

2.1 Demographic Questionnaire. Developed by the researcher to collect participants' background information, covering 10 items: sex, age, religion, marital status, educational level, professional level, years of nursing experience, years of experience in pediatric medication administration, participation in medication-related training, and weekly working hours.

2.2 Observation Checklist for Medication Administration Practice. Developed by the researcher to assess nurses' adherence to the Model across its three phases (pre-administration,



administration, and post-administration), with each item rated dichotomously as “performed” or “not performed” and a section for observational comments.

2.3 The Medication Administration Knowledge Test was developed by the researcher to assess nurses' knowledge and consists of 20 items divided into four domains. The first domain, general medication knowledge, comprises 4 items with a score range of 0 – 4, classified as high (3.01 – 4.00), moderate (2.01 – 3.00), or low (1.00 – 2.00). The second domain, pre-medication assessment, comprises 5 items with a score range of 0 – 5, classified as high (3.68 – 5.00), moderate (2.34 – 3.67), or low (1.00 – 2.33). The third domain, administration procedures, likewise comprises 5 items with a score range of 0 – 5, classified as high (3.68 – 5.00), moderate (2.34 – 3.67), or low (1.00 – 2.33). The fourth domain, participatory administration, comprises 6 items with a score range of 0 – 6, classified as high (4.34 – 6.00), moderate (2.68 – 4.33), or low (1.00 – 2.67). Each item was scored dichotomously, with a correct response scored as 1 and an incorrect response scored as 0, yielding a total possible score range of 0 – 20, with overall knowledge classified as high (14 – 20), moderate (7 – 13), or low (0 – 6).

2.4 The Satisfaction Questionnaire was developed by the researcher to assess nurses' satisfaction and consists of six items: easy of implementation, clarity and understandability, usefulness for work performance, effectiveness in error prevention, practical applicability, and overall satisfaction. Each item was rated on a five-point Likert scale (5 = highest, 1 = lowest), with mean scores classified as highest (4.51 – 5.00), high (3.51 – 4.50), moderate (2.51 – 3.50), low (1.51 – 2.50), or lowest (1.00 – 1.50).

2.5 Medication Error Incident Record Form. Developed by the researcher to document the frequency and type of medication errors before and after implementation, covering seven categories: incorrect prescription, wrong dosage, wrong medication, wrong timing, wrong patient, incorrect administration method, and incorrect documentation/ reporting after patient refusal. “ Incorrect prescription” was included because pediatric nurses verify medication orders against established standards prior to administration, and discrepancies identified during this step were recorded as part of the unit's safety monitoring. Because total medication administrations were not tracked per period, errors are reported as case counts rather than an incidence rate.



Validity and Reliability of the Research Instruments

The content validity of the five data collection instruments, the demographic questionnaire, observation checklist, knowledge test, satisfaction questionnaire, and error incident record form, was evaluated by a panel of three experts: 1) a nursing faculty member from the Department of Pediatrics with expertise in medication administration, 2) a nursing supervisor and assistant head of the Nursing Quality Division specializing in medication safety, and 3) a pediatric faculty physician with the same expertise, following the approach described by Polit and Beck (2006). The scale-level Content Validity Index (S-CVI) was as follows: 0.90 for the demographic questionnaire, 0.93 for the observation checklist, 0.90 for the knowledge test, 0.80 for the satisfaction questionnaire, and 0.86 for the error incident record form.

The Medication Administration Knowledge Test's reliability was evaluated through a pilot study of 30 registered nurses with characteristics similar to the study participants. Internal consistency, determined using the Kuder–Richardson Formula 20 (KR-20), yielded a coefficient of 0.92, exceeding the commonly accepted 0.70 threshold (Nunnally & Bernstein, 1994). The Satisfaction Questionnaire, developed by the researcher and comprising six items rated on a five-point Likert scale, was also pilot-tested among 30 registered nurses with characteristics similar to those of the study participants. Its internal consistency was assessed using Cronbach's alpha coefficient, yielding a value of 0.90, indicating acceptable reliability.

Ethical Considerations

This study was approved by the Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University (Approval No. REC.66-270-15-7; approved August 2, 2023). The researcher explained the study's objectives, procedures, and potential risks and benefits to all eligible nurses; participation was voluntary, with written informed consent obtained from all participants, who were informed of their right to withdraw at any time without effect on their employment. All data were kept confidential and reported only in aggregate, de-identified form.

Data Collection

The data collection process was conducted in four phases as follows: 1) problem identification; 2) evidence retrieval and development of the practice guideline; 3) implementation of the guideline in clinical practice; and 4) evaluation of its implementation outcomes.



Phase 1: Problem identification

1. The researcher coordinated with the head nurse and registered nurses in the Pediatric Intensive Care Unit (PICU) at Songklanagarind Hospital, to explain the study objectives, potential benefits, participants' rights, and research procedures. Written informed consent was obtained from all participants before data collection.

2. A multidisciplinary development team comprising 11 members, including faculty physicians, medical interns, pharmacists, nurse medication safety champions, and advanced practice nurses, was established. The team reviewed and traced previous medication error incidents in the unit to identify existing problems and barriers using root cause analysis. The same 11 members subsequently served as the expert panel for the Delphi process.

3. Baseline data were collected by asking participants to complete a knowledge test on medication administration and medication error prevention in pediatric patients, together with a satisfaction questionnaire assessing the existing medication administration system before development of the Model. Completion of these instruments required approximately 40 minutes per participant.

Phase 2: Evidence retrieval and development of the practice guideline

4. The researcher and development team conducted a systematic search for evidence published between 2012 and 2022 using the PICO framework. Relevant research articles published in Thai and English were screened and selected as sources of evidence from PubMed, ThaiJO, and Google Scholar using search terms related to medication errors, medication administration, participatory models, pediatric intensive care nursing, drug events in intensive care units, pharmacology for nurses, nursing processes, model development, risk management, and nurses' job satisfaction. The quality of the selected evidence was appraised using the Joanna Briggs Institute (JBI) critical appraisal checklists appropriate to each study design. A draft Model was then evaluated using the Delphi technique by the same 11 members of the multidisciplinary development team over three rounds to achieve consensus on the components and practice items of the developed guideline. A consensus threshold of more than 75 % agreement was established. In Round 1, the experts evaluated the appropriateness of each item and provided comments and suggestions. The items were subsequently revised based on their feedback. In Round 2, the experts reassessed the revised items, and further modifications were made accordingly. Round 3 was conducted to confirm the experts'



opinions and establish consensus. Following completion of the three Delphi rounds, 21 of the 27 items (77.78 %) met the predefined consensus criterion of more than 75 % agreement. These items were incorporated into the final version of the clinical practice guideline.

5. The Model was subsequently introduced into clinical practice over a four-week implementation and refinement period through the following activities:

- Group Session 1: A 90 – minute meeting was conducted with all 33 participating nurses and the development team to explain the study objectives, discuss the proposed Model, and collaboratively define roles and responsibilities for implementation.

- Capacity Building: Two 90-minute training sessions covered commonly used medications, dosage calculations, and safe medication administration strategies to prevent medication errors. The Medication Administration Manual was also distributed to all participating nurses.

- Pilot Implementation and Observation: The Model was implemented in the PICU, and nursing practices were directly observed using an observation checklist covering the pre-administration, administration, and post-administration phases. Observations were conducted four times per week, with each session lasting 60 minutes, over a one-week period. All observations were conducted by the researcher, who was trained in the use of the observation checklist and its scoring criteria to ensure consistency in scoring.

- Group Session 2: A 90-minute meeting at the end of week four, attended by 33 participants, facilitated reflective discussion, identified implementation barriers, and refined the workflow.

Phase 3: Implementation of the guideline in clinical practice

6. Nurses' knowledge was assessed before and immediately after the training sessions to evaluate changes in knowledge following the educational intervention. Adherence to the established medication administration practice guidelines was continuously monitored throughout the implementation period, and necessary improvements were identified and addressed through periodic ward meetings. Relevant data were systematically collected and summarized to inform further refinement and development of the Model.



Phase 4: Evaluation of its implementation outcomes

7. Nurses' satisfaction with the developed Model was assessed after six months of implementation in clinical practice. The same questionnaire was administered to the same participants before and after the intervention.

8. The number of reported medication errors was evaluated by comparing medication error reports during the six-month periods before and after implementation of the developed Model.

Data Analysis

1. Descriptive statistics were used to summarize the data. Categorical variables were presented as frequencies and percentages, whereas continuous variables were reported as means and standard deviations. Differences in nurses' compliance with the unit's medication administration standards before and after implementation (Table 1) were described using frequencies and percentages only; no inferential statistical test was applied to these data.

2. Differences in nurses' knowledge and satisfaction scores, both overall and by individual domains, before and after implementation of the participatory medication administration model for preventing medication errors in the Pediatric Intensive Care Unit (PICU), Songklanagarind Hospital, were analyzed using the paired-samples t-test. Although the sample size was estimated a priori using a conventional significance level of $\alpha = .05$, statistical significance for hypothesis testing was set at the more conservative level of $p < .01$ to reduce the likelihood of Type I error given the number of comparisons conducted across multiple knowledge and satisfaction domains. Prior to conducting the paired-samples t-test, the assumption of normality was assessed by examining the distribution of the difference scores using the Shapiro – Wilk test.

3. The frequency of medication errors following implementation of the participatory medication administration model was analyzed using descriptive statistics.

Results

Part 1: Demographic Characteristics of the Registered Nurses

The study sample consisted of 33 registered nurses. All participants were female (100.00 %). The mean age was 31.6 years (S.D. = 8.27; range, 22.5 – 58.3 years). Most participants were Buddhist (84.85 %) and single (84.85 %). All participants held a bachelor's degree as their highest educational



qualification (100.00 %). The participants had a mean of 8.84 years of nursing experience (S.D. = 8.22; range, 1.2 – 36.2 years) and a mean of 8.64 years of experience in pediatric medication administration (S.D. = 8.26; range, 1.2 – 33.2 years). More than half of the participants (57.58 %) had attended one to two training programs on medication administration or medication errors after graduation. Twenty-eight participants (84.85 %) reported previous experience with medication errors. Most participants (63.64 %) worked between 41 and 50 hours per week.

Part 2: Frequency and Percentage of Nurses' Compliance with the Unit Medication Administration Standards Before and After Implementation of the Participatory Medication Administration Model

Comparison of nurses' medication administration practices before and after implementation of the participatory medication administration model showed that the percentage of nurses performing medication administration according to the established standards increased across most practice items compared with the pre-implementation period; no inferential statistical test was applied to these descriptive comparisons. The greatest improvement was observed in the practice of having two nurses independently verify medications at the patient's bedside before pressing the infusion pump Start button (Table 1).

Table 1 Nurse Compliance with Medication Standards Before and After Model Implementation (n = 33)

Nurse Compliance	Number of Nurses (%)			
	Before	Percentage	After	Percentage
1. Verify med card vs flow chart	29	87.88	33	100
2. Compare doctor order vs flow	30	90.91	33	100
3. Check allergy/history	31	93.94	33	100
4. Calculate dose in ml	28	84.85	32	96.97
5. Reprint med card if >3x changes	25	75.76	31	93.94
6. Double nurse check	30	90.91	33	100
7. Verify 1st time start	28	84.85	31	93.94
8. Check bedside med before start	25	75.76	32	96.97
9. Use 2 patient identifiers	29	87.88	32	96.97
10. Clear IV/TPN labeling	26	78.79	32	96.97



Nurse Compliance	Number of Nurses (%)			
	Before	Percentage	After	Percentage
11. No meds/syringes on poles	29	87.88	33	100
12. Reset pump for change	26	78.79	31	93.94
13. Handoff with drip follow-up	30	90.91	33	100
14. Use med cart + barcode scan	28	84.85	33	100
15. Record monitoring in HIS	29	87.88	32	96.97

Part 3: Comparison of Nurses' Knowledge Before and Immediately After Training on the Participatory Medication Administration Model

The overall knowledge score was significantly higher immediately after training than before training. When analyzed by domain, knowledge scores were significantly higher immediately after training than before training in general medication knowledge, medication assessment, and participatory medication administration ($p < .01$) (Table 2)

Table 2 Knowledge Scores Before and Immediately After Training on the Participatory Medication Administration Model (n = 33)

Knowledge Domain	Before			After			t	p-value
	Mean	S.D.	Level	Mean	S.D.	Level		
1. General knowledge of medications	3.27	0.52	high	3.97	0.17	high	-6.84	<.001*
2. Assessment in medication administration	4.03	0.85	high	4.82	0.39	high	-4.88	<.001*
3. Medication administration process	4.52	0.62	high	4.85	0.44	high	-2.96	0.01
4. Participatory medication administration by nurses	3.24	1.06	moderate	5.36	0.74	high	-9.80	<.001*
Overall knowledge score	15.06	1.71	High	19.00	1.27	high	-11.41	<.001*

Statistical test: Paired t-test; $p < .01$ was considered statistically significant



Part 4: Comparison of Nurses' Satisfaction Before and After Six Months of Model Implementation

Nurses' satisfaction with the newly developed participatory medication administration model was significantly higher after six months of implementation than their reported satisfaction with the prior medication administration practice at baseline ($p < .01$). Because the two assessments referred to different practices (the existing system at baseline versus the new model after six months of implementation, this finding is best interpreted as a more favorable perception of the new model relative to previous practice, rather than a change in satisfaction with an identical referent. Among the individual satisfaction items evaluated for the developed model, the highest-rated aspect was its practical applicability in clinical practice (mean = 4.67, S.D. = 0.54), followed by its usefulness in supporting nursing practice within the unit (mean = 4.64, S.D. = 0.55) (Table 3).

Table 3 Comparison of Nurse Satisfaction with Existing Practice (Before) and the Developed Participatory Medication Administration Model After Six Months of Implementation (n = 33)

Satisfaction Item	Before			After			t	p-value
	Mean	S.D.	Level	Mean	S.D.	Level		
1. Easy to implement	3.18	0.39	moderate	4.52	0.57	highest	-10.41	<.001*
2. Clear and understandable content	3.18	0.53	moderate	4.36	0.60	high	-8.02	<.001*
3. Useful for work performance	3.18	0.58	moderate	4.64	0.55	highest	-11.08	<.001*
4. Effective in error prevention	3.24	0.56	moderate	4.39	0.70	high	-7.93	<.001*
5. Practically applicable	3.33	0.54	moderate	4.67	0.54	highest	-10.41	<.001*
6. Overall satisfaction	3.33	0.54	moderate	4.55	0.56	highest	-9.41	<.001*

Statistical test: Paired t-test; $p < .01$ was considered statistically significant.

Part 5: Frequency of Medication Administration Errors Before and After Implementation of the Participatory Medication Administration Model

Medication error incident records were used to document the frequency of medication administration errors reported before and after implementation of the participatory medication



administration model, based on the hospital's incident reporting system. Because the total number of medication administrations was not tracked for each period, findings are presented as the number of reported cases rather than as an incidence rate, and no statistical comparison was performed. Fewer medication administration errors were reported after implementation of the participatory medication administration model for registered nurses in the Pediatric Intensive Care Unit (PICU) , Songklanagarind Hospital (Table 4).

Table 4 Frequency of Medication Administration Errors Before and After Implementation of the Participatory Medication Administration Model

Medication Error	Before Implementation (No. of Cases)	After Implementation (No. of Cases)
1. Incorrect prescription	10	2
2. Wrong dosage	4	1
3. Wrong medication	0	0
4. Wrong timing	1	0
5. Wrong patient	1	0
6. Incorrect administration method	1	1
7. Incorrect documentation/reporting after patient refusal	0	0

Discussion

More than half of the participants (57.58 %) had attended one to two training programs on medication administration or medication errors after graduation, consistent with the perceived facilitators identified in Sessions et al. (2019) , a qualitative study in which nurses perceived organizational and training support as helping to strengthen safe high-alert medication administration and reduce errors. The unit's existing orientation program for newly employed nurses already covers medication administration and error prevention, which may have given participants baseline knowledge that facilitated their engagement with, and learning from, the newly developed Model.

Nurses' compliance with medication administration standards improved across most practice items after implementation, consistent with Yatpramot et al. (2020), whose risk-management program



for preventing medication errors at Khao Wong Hospital, Kalasin Province, similarly achieved significantly higher practice scores. The Model's participatory nature—engaging nurses in developing practice agreements, training, and direct feedback through observation and group reflection—may have strengthened their sense of ownership and accountability for the agreed standards, contributing to the observed improvement.

Knowledge scores similarly rose, consistent with Yatpramot et al. (2020), whose 10 – step model development program likewise raised knowledge scores, and with Tonsook (2023); Radabutr et al. (2023), who found significantly higher post-intervention knowledge scores after structured medication administration training. This improvement likely reflects the combination of structured training, the unit – specific Medication Administration Manual, and hands-on pilot implementation with direct feedback – providing both theoretical understanding and applied practice, consistent with adult-learning principles that favor active participation over passive instruction.

Nurses reported high satisfaction with the Model, particularly its practical applicability and usefulness for nursing practice. Because satisfaction was assessed against existing practice at baseline and the new Model post-implementation, this reflects a favorable perception of the Model relative to prior practice rather than a straightforward pre-post increase in an identical construct—consistent with Tonsook (2023), whose high-alert medication management model in the Surgical Nursing Department of Surat Thani Hospital likewise achieved the highest satisfaction rating among 86.8 % of participants.

Reported medication administration errors also decreased after implementation, consistent with Tonsook (2023), who found a similar decrease in high-alert medication errors following a comparable nursing service model, and with Saenglersilpachai and Tapchaisri (2023), whose medication management system – including medication manuals, monitoring forms, and standardized information-access procedures – likewise reduced medication errors. This reduction may reflect the combined effect of the Model's structured verification steps (e.g., double-checking, standardized dosage calculation), accompanying training, and increased nurse engagement in monitoring and reporting medication safety issues.

They are also consistent with Onsaad (2023), whose PDCA-based medication error surveillance system at Huai Mek Hospital, Kalasin Province, significantly reduced medication administration errors. These findings should be interpreted cautiously, however, as this study lacked a control or



comparison group; observed improvements may partly reflect increased staff awareness from study participation rather than the Model's effects alone.

Limitations

1. Generalizability of the findings and single-site design: The model was developed and evaluated at a single center, the PICU of a tertiary referral hospital, where patient acuity, workload, staffing patterns, and the complexity of clinical care differ substantially from general wards or community hospitals. The findings should therefore be interpreted with caution when considering their applicability to other healthcare settings or clinical contexts.

2. Duration of follow-up and sustainability: The post-implementation evaluation was conducted over a relatively short period, so the long-term sustainability of changes in nurses' medication administration practices could not be fully determined. The observed improvements may also have been influenced by a temporary increase in staff awareness (a Hawthorne-type effect) associated with the introduction of the new model and the presence of direct observers during the pilot.

3. Accuracy of the medication error reporting system: The incidence of medication errors was determined solely from the hospital's incident reporting system. As with all voluntary reporting systems, the reported incidence may not fully reflect the actual occurrence of medication errors, since some events may have been underreported.

4. Uncontrolled external factors: Medication management is a multidisciplinary process involving several healthcare professionals. Potential external factors that may have influenced medication errors, including physician rotation, limitations of the hospital information system, and changes in medication packaging supplied by the hospital pharmacy, were not controlled for in this study.

5. Absence of a control or comparison group: This study used a single-group, pre-post design without a concurrent control or comparison group. As a result, the observed improvements in practice, knowledge, and error frequency cannot be attributed to the Model with certainty, since other factors occurring over the same period cannot be ruled out.



Conclusions

The participatory medication administration model was associated with improved nurses' knowledge and medication administration practices in the Pediatric Intensive Care Unit. Nurses also reported satisfaction with the developed model, particularly regarding its practical applicability and usefulness in clinical practice. In addition, fewer medication administration errors were observed after implementation. These findings suggest that a participatory approach involving multidisciplinary collaboration, shared responsibilities, and continuous learning may support safer medication administration practices in the PICU.

Implications and Recommendations

Implications of the Findings

Healthcare units with similar clinical contexts may consider establishing a medication safety committee or designating medication safety champions to monitor medication errors, clarify roles and responsibilities, and promote understanding of medication safety policies among healthcare personnel at all levels. In addition, key medication safety indicators should be monitored regularly, with medication safety information communicated and fed back to relevant healthcare professionals to support ongoing quality improvement.

Recommendations for Future Research

Future studies should evaluate the participatory medication administration model (or similar participatory approaches) in other clinical settings, using a comparison or control group and a longer follow-up period to assess the sustainability of its effects, before considering wider implementation. Future studies should also evaluate the effectiveness of the model in improving the satisfaction of pediatric patients and their caregivers.

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Declaration of Generative AI Use

In the preparation of this manuscript, the authors used ChatGPT and Gemini to improve sentence structure and refine the language in both the English and Thai versions of the manuscript. Following the use of these generative artificial intelligence (AI) tools, the authors carefully reviewed, revised, and verified all content. The authors accept full responsibility for the accuracy, integrity, and scientific validity of all information presented in this manuscript.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

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