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Nexus of Thai Health Sciences (NTHS)

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Nexus of Thai Health Sciences (NTHS) aims to publish academic works and study findings in health sciences integration, with an emphasis on research at the health system and policy level, interprofessional approaches, and the integration of knowledge across disciplines, in order to support the sustainable development and transformation of Thailand's health system and the professional development of Thai public health and medical personnel, at both national and international levels, as well as interested members of the general public.

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Nexus of Thai Health Sciences
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Instructions for Authors

Nexus of Thai Health Sciences (NTHS) welcomes articles in the health sciences related to health systems research, health policy analysis, interprofessional practice, digital health, epidemiology, health economics, and related fields, with an emphasis on work that contributes to the development and transformation of Thailand's health system at the system and policy level. Articles must not have been published elsewhere and must not be under consideration by another journal. The guidelines are as follows.

1. Aims and Scope of the Journal

The journal is a forum for researchers, academics, health personnel, and policy makers to exchange knowledge that links multiple professions, from health systems research and policy analysis to digital health and health system innovation. The scope of the journal covers the following areas:

- Health systems research and health policy analysis
- Interprofessional and multidisciplinary practice
- Public health and health promotion
- Digital health and health informatics
- Environmental and occupational health
- Public health education and health workforce development
- Social determinants of health
- Health economics and resource allocation
- Epidemiology and disease surveillance

2. Types of Articles Considered

Original research articles are reports of the authors' own studies and research, including research and development (R&D), action research, and the development of models or health service systems. They comprise the following sections in order: title; author names and affiliations; abstracts in Thai and English; introduction; research objectives; methods; results; discussion; conclusions; recommendations; acknowledgments (if any); and references.

Academic articles present academic knowledge, concepts, or experience in the health sciences, with analysis, synthesis, and reference to reliable empirical evidence. They comprise an introduction, content, conclusion, and references.

Review articles systematically gather and review knowledge on a topic from domestic and international journals or books. They comprise an introduction, search methods, the content reviewed, critique, conclusion, and references.

Policy analysis articles systematically analyze a health policy or measure using empirical evidence and an appropriate conceptual framework. They comprise an introduction and policy background, analytical framework or methods, analysis results, policy options and recommendations, conclusion, and references.

All article types must not exceed 15 A4 pages, including tables, figures, and references.

3. Manuscript Preparation

3.1 General Format

- Type in Microsoft Word on single-sided A4 paper and format according to the journal's template
- Use TH Sarabun New font, 16 points, with 2.54 cm margins on all sides
- Maximum length of 15 pages, including tables, figures, and references

3.2 Components of the Article

Title. The title should be short, concise, and informative, consistent with the objectives and content, in both Thai and English, without abbreviations.

Author names. List the names and affiliations of all authors in both Thai and English (no abbreviations), and identify the corresponding author with an e-mail address and a telephone number.

Abstract. Written in both Thai and English, no more than **300** words per abstract, as continuous prose without subdivision into items. It covers the background and objectives, methods, results, and conclusions; includes only key statistics; and contains no citations.

Keywords. In both Thai and English, **3–5** words, placed at the end of the abstract in each language and separated by commas (,).

Introduction. Describes the background and significance of the problem, the situation, related research, the knowledge gap, and the rationale for the study.

Methods. Describes the study design, population and sample, sample size calculation and selection, instruments and their quality testing, data collection, data analysis, and research ethics,

specifying the name of the human research ethics committee, the certificate number, and the date of approval.

Results. Present results in the order of the objectives. Use tables when there are many figures or variables, without repeating in the text the data shown in the tables, except for key findings. Table titles are placed above the table together with the sample size (n); figure or chart titles are placed below the figure.

Discussion and conclusions. Discuss the findings in relation to the objectives and hypotheses, explain the reasons for the results, cite relevant theories or studies, state the limitations of the study, and conclude the key findings in line with the objectives.

Recommendations. Suggestions for applying the findings in practice, administration, or policy, and recommendations for future research.

Acknowledgments (if any). Identify those who provided assistance, supporters, and sources of research funding.

4. Reference Style

The journal uses the Vancouver referencing style. Reference numbers are placed in square brackets [ ] at the end of the statement cited. Use number 1 for the first source cited and continue in order of appearance in the text. If a source is cited again, use the original number. Compile the complete reference list at the end of the article. Authors are responsible for the accuracy of their references. When a source has more than 6 authors, list the first 6 followed by "et al."

4.1 Journal Articles

Author(s). Article title. Journal name. Year of publication; Volume (Issue): First page-last page.

1. Nuannet P, Somboon O. Development of a primary health care system in rural communities. Thai Journal of Public Health. 2023;18(3):112-128.
2. Muangsapaya W, Winichagoon P, Fucharoen S, Pootrakul P, Wasi P. Improved technique for detecting intraerythrocytic inclusion bodies in thalassemic trait. J Med Assoc Thai. 1985;68:43-5.

4.2 Books and Textbooks

Author(s). Book title. Edition. City of publication: Publisher; Year of publication.

1. Ativanichayaphong N. Health policy and the Thai health service system. Bangkok: Thammasat University Press; 2022.
2. Gilstrap LC, Cunningham FG. Operative obstetrics. 2nd ed. New York: McGraw-Hill; 2002.

4.3 Book Chapters

Author(s). Chapter title. In: Editor(s), editor. Book title. City of publication: Publisher; Year of publication. p. First page-last page.

1. Wood WG. Hemoglobin analysis. In: Weatherall DJ, editor. The thalassemias. New York: Churchill Livingstone; 1983. p. 31-53.

4.4 Electronic Media and Articles with a DOI

Author(s). Article title. Journal name [Internet]. Year of publication [cited Year Month Day];Volume(Issue):Pages. Available from: URL

1. Annas GJ. Resurrection of a stem-cell funding barrier--Dickey-Wicker in court. N Engl J Med [Internet]. 2010 [cited 2010 Jun 15];363:1687-9. Available from: http://www.nejm.org/doi/pdf/10.1056/NEJMp1010466
2. Degenhardt L, Bohnert KM, Anthony JC. Assessment of cocaine and other drug dependence in the general population. Drug Alcohol Depend [Internet]. 2008 Mar [cited 2010 Apr 15];93(3):227-32. doi:10.1016/j.drugalcdep.2007.09.024

4.5 Theses and Dissertations

Author(s). Title [Type/degree level]. City of publication: University; Year degree awarded.

1. Srichairattanakool A. Comparison of the quality of life of patients with chronic myeloid leukemia in the chronic and blastic phases [master's thesis]. Bangkok: Chulalongkorn University; 2000.

5. Article Submission

Authors submit articles through the online system on the journal's website, registering as a member before submission and tracking the status of the article online at any time. Research articles involving human participants must state the name of the human research ethics committee and the approval number in the article. For further information, contact E-mail: fetp1yr@gmail.com

6. Review Process

- The editorial board checks that the article is consistent with the journal's aims and scope and with the manuscript preparation format
- Every article is reviewed by at least 3 peer reviewers with no conflict of interest with the authors, using a double-blind peer review process
- The editor decides to accept or reject an article primarily on the basis of academic quality and consistency with the journal's scope
- Authors revise the article according to the suggestions of the reviewers and the editorial board within the specified period and track the review outcome through the online system

7. Publication Fees

The journal charges an article processing charge only after an article has been accepted for publication. The editorial board will notify the payment channels together with the acceptance letter. The rates are as follows:

Thai-language article	English-language article
THB 4,500	THB 6,500

8. Publication Ethics

8.1 Editors' Ethics

Editors are responsible for deciding whether to accept or reject articles primarily on the basis of academic quality and consistency with the journal's scope, regardless of the authors' race, gender, nationality, religious belief, or institutional affiliation. They must keep articles under review confidential, withdraw from the review if they have a conflict of interest, and act appropriately when evidence of research misconduct, plagiarism, or duplicate submission is found, following the guidelines of the Committee on Publication Ethics (COPE).

8.2 Reviewers' Ethics

Reviewers must evaluate articles impartially, have expertise in the relevant field, and provide constructive suggestions. They must keep articles confidential, not use information in the articles for personal benefit, inform the editor of any conflict of interest or if an article is found to be significantly similar to other work, and accept the invitation and submit their review within the agreed time.

8.3 Authors' Ethics

Authors must certify that the article is original work that has not been published and is not under consideration by another journal; identify all contributors in accordance with the principles of authorship; report data and findings truthfully, without distorting, fabricating, or omitting significant data; disclose all types of conflicts of interest; and cite sources fully. Duplicate submission and plagiarism constitute serious violations of publication ethics.

8.4 Ethics of Research Involving Humans

Research articles involving humans must be approved by a human research ethics committee, and the approval number and committee name must be stated in the article. Research must be conducted under the principles of the Declaration of Helsinki, with informed consent from every participant, and with strict protection of personally identifiable information.

Responsibility

Articles and research reports published in Nexus of Thai Health Sciences represent the opinions and research of the authors alone, do not necessarily reflect the views of the editorial team, and are not the responsibility of Key Data Company Limited. All articles have undergone quality review according to research article standards by at least three peer reviewers using a double-blind process.

Nexus of Thai Health Sciences
Vol.1 No.5 September – October 2026

Editorial

Nexus of Thai Health Sciences (NTHS), Volume 1 Issue 5 (September – October 2026), is the issue that the editorial board is extremely proud to present to readers. The journal was founded to serve as an academic forum for research at the health system and policy level. Thailand's health system faces multidimensional challenges, including an aging society, the burden of chronic non-communicable diseases, inequity in access to services, and the transition to a digital health system. These challenges cannot be solved from the perspective of any single profession alone.

The name "Nexus" reflects the journal's intention to be a point of connection among frontline practitioners, researchers, academics, and policy makers. The scope of the journal therefore ranges from health systems research and policy analysis, interprofessional practice, public health and health promotion, digital health and health informatics, environmental and occupational health, health workforce development, social determinants of health, and health economics, to epidemiology and disease surveillance. Four article types are considered: original research articles, academic articles, review articles, and policy analysis articles.

Every article in this issue has been reviewed by at least 3 experts through double-blind peer review to ensure academic quality and credibility, and the journal is published as open access so that readers of all groups can access knowledge free of charge. The editorial board sincerely hopes that the knowledge in these articles will benefit the development of services, administration, and health policymaking, and can be applied concretely in readers' working contexts.

The editorial board thanks all authors who entrusted us with their work, the reviewers who gave their valuable time to review and provide suggestions, the advisors and all editorial board members, and Key Data Company Limited for helping make this first issue a success. The journal welcomes articles from academics and health personnel in all fields and looks forward to suggestions for improving the quality of the journal.

Corporal Arthawit Noenchard

Executive Editor

Nexus of Thai Health Sciences

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ORIGINAL ARTICLE

Effects of a Health Promotion Program Applying the Health Belief Model and Community Participation on Health Behaviors and Fasting Blood Glucose among People at Risk of Diabetes, Bannonchai Subdistrict Health Promoting Hospital, Mueang District, Kalasin Province, Thailand

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Abstract

This one-group pretest-posttest quasi-experimental study examined the effects of a health promotion program applying the Health Belief Model and community participation on knowledge, health behaviors, health beliefs, and clinical indicators among people at risk of diabetes. It was conducted in the catchment area of Ban Nonchai Subdistrict Health Promoting Hospital, Mueang District, Kalasin Province, from January to July 2025. The sample comprised 34 people with fasting blood glucose of 100-125 mg/dL, selected by simple random sampling from 120 eligible people. The intervention was a five-month health promotion program. Data were collected using questionnaires and health examinations before and after the program and analyzed using descriptive statistics and the paired t-test. After the program, health behavior scores increased from 62.68±16.42 to 93.85±10.28 (mean difference 31.17, 95% CI 25.76-36.58, p <.001, Cohen's dz 2.01), knowledge scores from 9.29±2.84 to 12.47±1.65, and health belief scores from 54.51±8.24 to 61.22±6.15 (both p <.001). Fasting blood glucose decreased from 108.65±12.47 to 98.24±9.85 mg/dL (95% CI -13.99 to -6.83, p <.001, dz 1.02); body weight, body mass index, and waist circumference decreased by 2.63 kg, 1.04 kg/m², and 3.39 cm, respectively (all p <.001). The mean satisfaction score was 21.84±2.18 out of 25 (87.36%). After the program, participants showed improved knowledge, behaviors, beliefs, and clinical indicators; a controlled study is needed before wider implementation.

Keywords: diabetes risk group, health promotion, Health Belief Model, subdistrict health promoting hospital

Introduction

Diabetes mellitus is a chronic non-communicable disease and a major global public health problem. The International Diabetes Federation (IDF) reported that in 2024 approximately 589 million adults aged 20-79 years, or 1 in 9, were living with diabetes, and that this number is projected to rise to 853 million by 2050.[1,2] In addition, approximately 488 million adults have impaired fasting glucose, which places them at high risk of type 2 diabetes.[2] In Thailand, approximately 6.36 million adults have diabetes, with an age-adjusted prevalence of 10.20%, and 33.30% of those affected remain undiagnosed.[2] Type 2 diabetes can be prevented or delayed through lifestyle modification, namely a suitable diet, regular physical activity, and maintaining a healthy body weight.[3,4]

According to Health Data Center (HDC) data for 2024,[5] screening of people aged 35 years and over found that the proportion of people at risk of diabetes was 14.80% in Kalasin Province and 13.60% in Mueang Kalasin District. In the catchment area of Ban Nonchai Subdistrict Health Promoting Hospital (Ban Nonchai SHPH), Khamin Subdistrict, there were 120 people at risk of diabetes out of 98 people screened in total. Most residents work in agriculture and live according to the rice-farming seasons. The community holds certain traditional health beliefs and favors strongly flavored, high-sugar foods, which may hinder behavior change.

The Health Belief Model explains that individuals adopt disease-preventive behaviors when they perceive their susceptibility to and the severity of the disease, perceive the benefits of and barriers to action, have the self-efficacy to act, and receive appropriate cues to action.[6] This theory has been widely applied in diabetes prevention programs. In Thailand, behavior modification models for diabetes prevention have been developed for at-risk groups,[4] and the application of health literacy together with empowerment[7] and health literacy promotion programs[8] increased the preventive behavior scores of at-risk participants to levels significantly higher than those of control groups. However, studies applying the Health Belief Model together with community participation in the context of subdistrict health promoting hospitals (SHPHs) in Kalasin Province remain limited.

SHPHs are primary care facilities close to the public that work with village health volunteers (VHVs) and community leaders,

and therefore play an important role in health promotion and in preventing new cases of diabetes. The researcher therefore studied the effects of a health promotion program for people at risk of diabetes at Ban Nonchai SHPH. The findings provide information for planning diabetes prevention work and serve as baseline data for subsequent controlled studies.

Research Objectives

1) To describe the general characteristics and baseline health status of people at risk of diabetes
2) To develop and implement a health promotion program for people at risk of diabetes applying the Health Belief Model together with community participation
3) To compare knowledge, health behaviors, health beliefs, and clinical indicators before and after participation in the program
4) To evaluate participants' satisfaction with the program

Hypotheses: 1) Knowledge, behavior, and belief scores after the program are higher than before. 2) Fasting blood glucose, body weight, body mass index, and waist circumference after the program are lower than before.

Methods

This was a quasi-experimental study with a one-group pretest-posttest design, conducted in the catchment area of Ban Nonchai SHPH from January to July 2025. Pre-intervention data were collected in January, the program ran for 5 months (February-June), and post-intervention data were collected in July, within 2 weeks after the final activity. The same assessors and instruments were used before and after the program. Because there was no comparison group, the results reflect pre-post changes only.

Population

People at risk of diabetes residing in the catchment area of Ban Nonchai SHPH in January 2025 who were screened and found to have fasting blood glucose of 100-125 mg/dL (prediabetes), totaling 120 people, with the values confirmed by repeat testing before inclusion.

Sample

The sample of 34 people was selected by simple random sampling, by drawing lots without replacement from the list of people who met the inclusion criteria. The sample size was calculated using G*Power with the t-test for the difference between two dependent means (matched pairs), two-tailed, assuming a medium effect size (dz = 0.50) according to Cohen's criteria,[9] a significance

level of 0.05, and a power of 0.80, which gave a sample size of 34 (actual power 0.81). No one declined to participate, and no allowance was made for attrition.

Inclusion Criteria

1) Aged 35-59 years (working age, at high risk and able to take part in group activities); 2) fasting blood glucose of 100-125 mg/dL; 3) never diagnosed with diabetes, as verified from medical records and the JHCIS program; 4) residing in the area throughout the study period; 5) able to communicate, read, and write Thai; 6) not taking medication that affects blood glucose and not participating in another weight-control program during the same period; and 7) willing to participate voluntarily.

Exclusion Criteria

Having complications or comorbidities that limit exercise, as screened by a registered nurse using the Physical Activity Readiness Questionnaire (PAR-Q) before the start of the program.

Discontinuation Criteria

1) Pregnancy during the study; 2) moving out of the area; 3) withdrawal; or 4) attending fewer than 80% of all activities (5 sessions as shown in Table 1; attendance was recorded at each session by research assistants). The number of participants who discontinued and their reasons will be reported in the results.

Conceptual Framework

The independent variable was the health promotion program. The dependent variables were knowledge, health behaviors, health beliefs, clinical indicators (fasting blood glucose, body weight, body mass index, and waist circumference), and satisfaction. Each program activity corresponded to a component of the theory (Table 1). Community participation referred to community leaders and VHVs taking part in planning, mentoring, and following up participants.

Intervention Program

The 5-month health promotion program for people at risk of diabetes was divided into three sub-phases: knowledge foundation (month 1), skill development (months 2-4), and sustainability reinforcement (month 5). The researcher developed it from a literature review and the local context, and three experts reviewed its appropriateness. Activities were delivered by the researcher together with trained VHVs once a month in groups of approximately 17 people, for a total program contact time of 420 minutes (7 hours). Home visits, telephone calls, a LINE group, and monthly health checks with feedback served as cues to action, as shown in Table 1.

Table 1 Activities of the health promotion program for people at risk of diabetes

Month	Activities/Content	HBM Component	Tools Used	Duration per Session
1	Knowledge foundation phase: orientation; education on diabetes and its risk factors; demonstration of self-monitoring of blood glucose; personal health care planning; and the "Health Learning House," using community leaders and VHVs as mentors	Perceived susceptibility and severity	Presentation media, health handbook, fingertip glucometer	120 min
2	Skill development phase: nutrition management ("Healthy Community Kitchen")	Perceived benefits and reduced barriers	Local foods, herbs and spices, cooking demonstration media	90 min
3	Skill development phase: group exercise and the "Big Sibling Helps Little Sibling" buddy group	Self-efficacy	Locally available equipment, e.g., water bottles used as weights	60 min
4	Skill development phase: stress and emotion management	Self-efficacy and reduced psychological barriers	Relaxation demonstration media, stress diary form	60 min
5	Sustainability reinforcement phase: building a community support network; review of knowledge and skills; "Harvesting Success"	Cues to action and social support	Health diary, LINE group	90 min
1-5	Follow-up through home visits, telephone calls, and the LINE group, with monthly health checks	Cues to action	Home visit record form, blood pressure monitor, glucometer	Scheduled monthly

Data Collection Instruments

1) General information questionnaire; 2) diabetes knowledge questionnaire of 15 items, scored 1 for a correct answer and 0 for an incorrect answer (maximum 15); 3) health behavior questionnaire of 40 items, 3 points per item (maximum 120); 4) health belief questionnaire of 25 items, 3 points per item (maximum 75); 5) program satisfaction questionnaire of 5 items, 5 points per item (maximum 25) [specify the source of each instrument]; and 6) health examinations, namely body weight, height, waist circumference, and fasting blood glucose,

measured by trained research assistants (not the activity facilitators) using the same calibrated weighing scale, tape measure, and fingertip glucometer before and after the program, after fasting for at least 8 hours. Blood pressure was measured for safety before exercise and was not analyzed.

Score interpretation criteria, based on the percentage of the maximum score: low <60.00, moderate 60.00-79.99, and good ≥80.00 (applied to knowledge, behavior, belief, and satisfaction).

Instrument Quality Assessment

Content validity of all instruments was examined by three experts, with Index of Item-Objective Congruence (IOC) values of 0.67-1.00 (criterion ≥0.50; reported separately for each instrument). The instruments were piloted with 30 people with characteristics similar to the sample. The Kuder-Richardson 20 (KR-20) of the knowledge questionnaire was 0.78, and Cronbach's alpha coefficients of the health behavior, health belief, and satisfaction questionnaires were 0.89, 0.85, and 0.91, respectively. The item difficulty of the knowledge questionnaire was 0.74 and its discrimination was 0.58; reliability in the study sample was 0.74.

Data Collection

Data collection was divided into three phases. 1) Phase 1 (January 2025): permission to conduct the study was requested; community leaders and VHVs were coordinated; three research assistants were trained (1 day on standardized body measurement and questionnaire administration); the sample was selected; the study was explained and informed consent obtained; and pre-intervention data were collected (pre-test). 2) Phase 2 (February-June 2025): the program was implemented with follow-up through home visits, telephone calls, the LINE group, and monthly health checks. 3) Phase 3 (July 2025): post-intervention data were collected (post-test) with the same instruments, and satisfaction was assessed. Using the same questionnaires may have produced a testing effect.

Data Analysis

General data were analyzed using descriptive statistics, namely frequency, percentage, mean (M), and standard deviation (SD). Mean differences before and after the program were compared using the paired t-test, after checking the normality of the differences with the Shapiro-Wilk test (variables that were not normally distributed were analyzed with the Wilcoxon signed-rank test and reported as median (IQR)). The mean difference (post minus pre), the 95% CI of the difference, t, df, and Cohen's dz effect size were reported. Because 7 indicators were tested, fasting blood glucose was designated the primary indicator, and the Bonferroni criterion (0.05/7 = 0.007) was used for checking. The significance level was set at

p <.05, two-tailed. Analyses were performed using R.

Research Ethics

This study was approved by the Human Research Ethics Committee of the Kalasin Provincial Public Health Office. The researcher protected participants' rights by 1) explaining the study objectives and procedures; 2) obtaining signed informed consent; 3) keeping data confidential and presenting results in aggregate; and 4) allowing participants to withdraw at any time without affecting their access to health services. Readiness for exercise was screened beforehand, and a plan was in place for managing adverse events.

Results

1. General Characteristics and Baseline Health Status of People at Risk of Diabetes

1.1 Personal Characteristics

The 34 participants had a mean age of 52.35±6.18 years (minimum-maximum 45-54 years). Most were female, married, had completed primary education, and worked in agriculture. Participants with a family history of diabetes accounted for 38.24%, as shown in Table 2.

Table 2 Personal characteristics of the sample (n = 34)

Characteristic	Number	Percent
Female	24	70.59
Married	26	76.47
Primary education	18	52.94
Agricultural occupation	22	64.71
Family history of diabetes	13	38.24

1.2 Baseline Health Status Before the Program

Participants' mean fasting blood glucose was 108.65±12.47 mg/dL (minimum-maximum 100.00-125.00), mean body weight was 66.74±8.91 kg, mean body mass index was 26.38±3.12 kg/m², and mean waist circumference was 88.46±8.12 cm. The mean diabetes knowledge score was 9.29±2.84 (61.93%, moderate level), the mean health behavior score was 62.68±16.42 (52.23%, low level), and the mean health belief score was 54.51±8.24 (72.68%, moderate level).

2. Health Promotion Program for People at Risk of Diabetes

2.1 Program Structure and Activities

The program applied the Health Belief Model together with community participation

over 5 months, divided into three sub-phases, with continuous follow-up through home visits, telephone calls, and the LINE group, as shown in Table 1.

2.2 Program Implementation Results

All 34 participants completed the program (100.00%); no one discontinued and there were no missing data, so data from all 34 participants were analyzed for every variable. Obstacles were encountered during implementation and the program was adjusted accordingly (based on the researcher's field notes), as follows:

1) Pre-existing health understanding and beliefs, addressed through the "Health Learning House" activity, with community leaders and VHVs as mentors
2) Taste preferences for local food, addressed through the "Healthy Community Kitchen" activity
3) The farming season, addressed by making the activity schedule flexible and holding sessions in the evening
4) Budget constraints, addressed by using locally available exercise equipment
5) Use of the LINE group among older adults, addressed through the "Big Sibling Helps Little Sibling" buddy group and a monthly "Harvesting Success" activity

3. Effects of the Program on Knowledge, Health Behaviors, Health Beliefs, and Clinical Indicators

3.1 Knowledge, Health Behaviors, and Health Beliefs

After the program, the mean diabetes knowledge score increased by 3.18 points (95% CI 2.29-4.07; t = 7.23, df = 33, p <.001; dz = 1.24), from the moderate to the good level (83.13%). The health behavior score increased by 31.17 points (95% CI 25.76-36.58; t = 11.73, df = 33, p <.001; dz = 2.01), from the low to the moderate level (78.21%), and the health belief score increased by 6.71 points (95% CI 4.01-9.41; t = 5.05, df = 33, p <.001; dz = 0.87), from the moderate to the good level (81.63%), as shown in Table 3.

Table 3 Comparison of mean knowledge, health behavior, and health belief scores before and after the program (n = 34)

Variable	Before		After		Mean difference (95% CI)	t	p
	M	SD	M	SD			
Diabetes knowledge (max 15)	9.29	2.84	12.47	1.65	3.18 (2.29-4.07)	7.23	<.001*
Health behavior (max 120)	62.68	16.42	93.85	10.28	31.17 (25.76-36.58)	11.73	<.001*
Health belief (max 75)	54.51	8.24	61.22	6.15	6.71 (4.01-9.41)	5.05	<.001*

Note: *p <.05

3.2 Clinical Indicators

After the program, fasting blood glucose decreased by 10.41 mg/dL (95% CI 6.83-13.99; t = -5.92, df = 33, p <.001; dz = 1.02). Twenty of the 34 participants (58.82%; 95% CI 40.70-75.35) had glucose below 100 mg/dL, and none had glucose reaching the diagnostic threshold for diabetes (≥126) (0 of 34; 95% CI 0.00-10.28). Body weight decreased by 2.63 kg (3.94% of baseline weight; 95% CI 1.66-3.60; t = -5.50, p <.001; dz = 0.94), with 6 of 34 participants (17.65%; 95% CI 6.76-34.53) losing ≥5.00%. Body mass index decreased by 1.04 kg/m² (95% CI 0.70-1.38; t = -6.22, p <.001; dz = 1.07), and waist circumference decreased by 3.39 cm (95% CI 2.14-4.64; t = -5.52, p <.001; dz = 0.95), as shown in Table 4.

Table 4 Comparison of mean clinical indicators before and after the program (n = 34)

Variable	Before		After		Mean difference (95% CI)	t	p
	M	SD	M	SD			
Fasting blood glucose (mg/dL)	108.65	12.47	98.24	9.85	-10.41 (-13.99 to -6.83)	-5.92	<.001*
Body weight (kg)	66.74	8.91	64.11	8.62	-2.63 (-3.60 to -1.66)	-5.50	<.001*
Body mass index (kg/m²)	26.38	3.12	25.34	3.01	-1.04 (-1.38 to -0.70)	-6.22	<.001*
Waist circumference (cm)	88.46	8.12	85.07	7.84	-3.39 (-4.64 to -2.14)	-5.52	<.001*

Note: Paired t-test (df = 33); the difference is post minus pre; *p <.05; dz = Cohen's dz (absolute value)

3.3 Satisfaction with the Program

The 34 participants reported a good level of satisfaction with the program, with a mean score of 21.84±2.18 out of 25 (87.36%; 95% CI 21.08-22.60).

Discussion

The participants' mean fasting blood glucose of 108.65 mg/dL falls within the range of prediabetes (impaired fasting glucose),[3] together with a mean body mass index of 26.38 kg/m², which meets the criterion for obesity class I for Asians (BMI ≥25.00).[10] Of the 34 participants, 22 (64.71%) had a BMI ≥25.00, consistent with the modifiable risk factors of overweight and unhealthy health behaviors. Knowledge, behavior, and belief scores before

the program were at the low to moderate level.

The program applied the Health Belief Model[6] together with community participation, using community leaders and VHVs as mentors and activities consistent with the local way of life and local food. Community participation is an important factor in the success of community health systems.[11] The fact that all 34 participants (100.00%) completed the program may be related to the flexible activity schedule adapted to the farming season and to follow-up through home visits, telephone calls, and the LINE group. However, participants were volunteers and were closely monitored (Hawthorne effect), so the retention rate may be higher than in real-world settings.

After the program, knowledge, health behavior, and health belief scores increased significantly, consistent with studies applying health literacy together with empowerment[7] and a health literacy promotion program,[8] which found higher knowledge and behavior scores after the intervention than before. The effect sizes were relatively large (dz 0.87-2.01) despite a total program contact time of only about 7 hours, which may be related to the monthly follow-up, repeated measurement with the same questionnaires, and self-assessment.

The 10.41 mg/dL decrease in fasting blood glucose is consistent with a study reporting reduced blood glucose in the experimental group.[7] This result may be related to changes in dietary behavior and exercise, but this study did not measure these directly, so the mechanism cannot be concluded. In addition, participants were selected because of high glucose values, so repeated measurements tend to decrease on their own (regression to the mean). Body weight decreased by 3.94% of baseline, which is below the ≥5.00% weight-loss target used in diabetes prevention programs.[12,13]

However, this study has the following limitations: 1) it used a single-group design without a control group, so the effects of the program cannot be separated from those of time, season, retesting, and regression to the mean, and causality cannot be concluded; 2) the sample was small (34 people), the confidence intervals were wide, and multiple indicators were tested; 3) data were collected in a single area from volunteers; 4) follow-up was short, and there were no data on new-onset diabetes; and 5) self-reported questionnaires were used, and assessors could not be blinded to receipt of the program.

Conclusion

In conclusion, after participating in the health promotion program applying the Health Belief Model together with community participation, the 34 at-risk participants had

increased knowledge, health behavior, and health belief scores ($p < .001$). Fasting blood glucose decreased from 108.65 to 98.24 mg/dL (difference 10.41; 95% CI 6.83-13.99); body weight, body mass index, and waist circumference decreased by 2.63 kg, 1.04 kg/m², and 3.39 cm, respectively; and participants were satisfied with the program at a good level (87.36%).

Recommendations

1. Recommendations for applying the findings: the program should be retested in a controlled study before scale-up, or scaled up as a pilot with evaluation in areas with similar contexts, whereby
   a) SHPHs and health service units should allocate budget and personnel continuously and develop a database system for monitoring at-risk people
   b) Local administrative organizations should integrate budgets and support venues and exercise equipment
   c) VHVs should develop counseling skills and act as leaders of health networks
   d) At-risk people and their families should continue healthy behaviors and attend scheduled health checks
2. Recommendations for future research: studies should use a controlled design (randomized or cluster-based), enlarge the sample, follow participants for 12 months to assess new-onset diabetes (fasting glucose ≥126 or HbA1c ≥6.5), directly measure dietary intake and physical activity, and evaluate the process and cost-effectiveness.

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ORIGINAL ARTICLE

Development of a Care Model for Pregnant Women with Iron Deficiency Anemia and Underweight in the Catchment Area of Ban Nonrang Subdistrict Health Promoting Hospital, Sawathi Subdistrict, Mueang District, Khon Kaen Province

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Abstract

This action research aimed to analyze the situation, develop a care model, and evaluate its appropriateness and outcomes for pregnant women with iron deficiency anemia who were underweight, applying PDCA quality cycle. The study was conducted in the catchment area of Ban Nonrang Subdistrict Health Promoting Hospital, Sawathi Subdistrict, Mueang District, Khon Kaen Province, over two action cycles from March to May 2025. Eight members of the multidisciplinary team and subdistrict network partners were purposively selected as co-researchers, and all six eligible pregnant women were enrolled. Instruments were focus group guidelines, a clinical record form (hemoglobin [Hb], hematocrit [Hct], mean corpuscular volume [MCV], and body weight), a self-care behavior assessment, a model appropriateness assessment, and a satisfaction questionnaire. Qualitative data were analyzed by content analysis and quantitative data by descriptive statistics and the paired t-test, with Hb as the primary outcome. The model, named NONRANG, comprised seven components: Nutritional assessment, Orem-based care plan, Nursing activities, Relatives' involvement, Active follow-up, Network coordination, and Goal evaluation. Three experts rated its appropriateness at the highest level (4.48±0.36). After implementation, Hb increased from 9.80±0.42 to 10.82±0.54 g/dL ($t = 5.09$, $df = 5$, $p = .004$; 95% CI of the difference 0.50-1.54), Hct from 30.00±1.26 to 34.67±1.62% ($p < .001$), and MCV from 78.90±3.10 to 83.20±3.40 fL ($p = .023$, not significant after α adjustment). All six women (100.00%; 95% CI 54.07-100.00) had weight within the green zone of the Vallop Curve. Self-care behavior scores increased from 51.67±5.84 to 78.42±4.28 ($p < .001$), and satisfaction was at the highest level (4.49±0.41). The model was appropriate and favorable changes in clinical and behavioral outcomes were observed; however, with $n = 6$ and no comparison group, effectiveness cannot be concluded, and larger studies with a comparison group are needed.

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Keywords: iron deficiency anemia, pregnant women, underweight, action research, Orem's self-care deficit nursing theory

Introduction

Iron deficiency anemia in pregnancy is a major global public health problem. The World Health Organization (WHO) defines anemia in pregnancy as a hemoglobin concentration below 11.00 g/dL in the first and third trimesters, or below 10.50 g/dL in the second trimester.[1] The main cause is the increased iron requirement during pregnancy to support red blood cell production and fetal growth.[2] In Thailand, the prevalence of anemia among pregnant women has tended to rise, at 14.29%, 14.69%, and 15.56% in 2022–2024, respectively, while in Mueang District, Khon Kaen, it was 13.92%, 14.93%, and 27.59%, respectively.[3] The condition affects both mother and infant: mothers are at risk of heart failure, infection, and postpartum hemorrhage, while infants are at risk of fetal growth restriction, low birth weight, and hypoxia.[4] Key risk factors include inadequate dietary iron intake, irregular use of prenatal supplements, poor pre-pregnancy nutritional status, and socioeconomic factors.[5]

Pregnant women who are underweight before pregnancy, particularly those with a body mass index (BMI) below 18.50 kg/m², are at high risk of fetal growth restriction, low birth weight, and preterm birth.[6] These women should gain 12.50–18.00 kg over the course of pregnancy according to the Institute of Medicine criteria[7] and be monitored with the maternal weight-gain chart (Vallop Curve), which is the standard used in Thailand.[8] Iron deficiency anemia coexisting with underweight is therefore a compounded risk that requires close and continuous care. In the catchment area of Ban Nonrang Subdistrict Health Promoting Hospital (SHPH), Sawathi Subdistrict, Mueang District, Khon Kaen Province, the researcher identified six pregnant women with iron deficiency anemia and underweight, all of whom were primigravidas, with a mean age of 21.33 years and a mean pre-pregnancy BMI of 17.84 kg/m².

Orem's Self-Care Deficit Nursing Theory explains that humans have the capacity for self-care and that nurses help when a self-care deficit arises, that is, when self-care demand exceeds self-care agency.[9] In pregnant women with anemia and underweight, self-care deficits include inappropriate dietary behavior, irregular medication intake, and a lack of self-care knowledge.[10] Studies applying this theory found that pregnant women improved their self-care behaviors, increased their hemoglobin levels, and adhered better to medication.[11] In addition, support from husbands and families is associated with better self-care behavior and rising hemoglobin levels,[12] consistent with the family-centered care concept.[13]

The PDCA (Plan-Do-Check-Act) quality cycle[14] is a framework for continuous quality improvement. When used to develop antenatal care services at SHPHs, it was reported to reduce anemia rates and increase attendance at scheduled antenatal visits.[15] However, most studies have been conducted in hospitals, and there remains a lack of proactive care models

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that systematically integrate self-care theory, family involvement, and community networks at the SHPH level.

SHPHs are primary care units with a central role in providing quality antenatal care, in which professional nurses assess health, monitor anemia, provide education, and coordinate referral when abnormalities are found.[6] The researcher therefore developed a care model for pregnant women with iron deficiency anemia and underweight in the catchment area of Ban Nonrang SHPH through an action research process involving the multidisciplinary team, network partners, and families. The findings will provide empirical evidence for planning maternal and child health services and for scaling up to areas with similar contexts.

Research Objectives

1) To analyze the situation and problems in the care of pregnant women with iron deficiency anemia and underweight in the catchment area of Ban Nonrang SHPH
2) To develop a care model for pregnant women with iron deficiency anemia and underweight by applying Orem's Self-Care Deficit Nursing Theory together with the PDCA quality cycle
3) To evaluate the appropriateness of the model and compare outcomes before and after its implementation, namely clinical values, self-care behavior, and satisfaction with the model

Research Methods

This study was action research following Kemmis and McTaggart,[16] in which each cycle comprised four steps: planning (Plan), action (Act), observation (Observe), and reflection (Reflect), or PAOR (corresponding to Plan, Do, Check, and Act of the PDCA cycle, respectively). Two cycles were conducted in the catchment area of Ban Nonrang SHPH, Sawathi Subdistrict, Mueang District, Khon Kaen Province, from March to May 2025, a total of 3 months. Clinical values were measured before implementation of the model (week 0) and at the end of the second cycle. The study applied Orem's Self-Care Deficit Nursing Theory[9] together with the PDCA quality cycle.[14] Because the researcher was both practitioner and data collector, laboratory values were used as the primary outcome to reduce observer bias. Details are as follows.

Population and Sample

Population

The population comprised pregnant women receiving antenatal care at Ban Nonrang SHPH from March to May 2025, together with the multidisciplinary team and subdistrict network partners involved in maternal and child health work.

Sample

The sample comprised two groups. Group 1 was the multidisciplinary team of Ban Nonrang SHPH (5 persons) and subdistrict network partners (3 persons), namely village health volunteers (VHVs), the subdistrict headman (kamnan), and village headmen, totaling 8 persons, who were

purposively selected to serve as the research team.

Group 2 was six pregnant women with iron deficiency anemia and underweight receiving antenatal care at Ban Nonrang SHPH, selected by total enumeration of all women who met the criteria during the study period; therefore, no sample size calculation was performed. Group 1 members were co-researchers and were not included in the before–after comparison.

Inclusion Criteria

1) Receiving antenatal care and under the care of Ban Nonrang SHPH; 2) iron deficiency anemia, defined as hemoglobin below 11.00 g/dL in the first and third trimesters or below 10.50 g/dL in the second trimester,[1,2] together with MCV below 80 fL or serum ferritin below 15 µg/L;[17] 3) underweight, defined as pre-pregnancy BMI below 18.50 kg/m²;[6] and 4) voluntary consent to participate in the research.

Exclusion Criteria

1) Confirmed thalassemia or thalassemia trait, because the prevalence of thalassemia trait is high in northeastern Thailand and can lower MCV for reasons other than iron deficiency;[18] 2) severe anemia (Hb below 7.00 g/dL) or acute blood loss; 3) multiple pregnancy or severe comorbidity; and 4) relocation out of the area or inability to be followed up throughout the study period.

Research Instruments

The research instruments were divided into two parts: 1) the instrument used to implement the research, namely the prototype care model for pregnant women with iron deficiency anemia and underweight (NONRANG Model), jointly developed by the research team, together with a nutrition handbook adapted to the Isan community context.

2) Data collection instruments, namely (1) a general information form, (2) focus group discussion guidelines, (3) a clinical record form (hemoglobin [Hb], hematocrit [Hct], mean corpuscular volume [MCV], and body weight according to the Vallop Curve nutrition chart), (4) a self-care behavior assessment, (5) a model appropriateness assessment, and (6) a satisfaction questionnaire. Items (5) and (6) used a five-point rating scale, with mean scores interpreted as 4.21–5.00 = highest, 3.41–4.20 = high, 2.61–3.40 = moderate, 1.81–2.60 = low, and 1.00–1.80 = lowest. All instruments were checked for content validity by three experts, piloted before actual use, and the reliability of the behavior assessment and questionnaire was examined using Cronbach's alpha coefficient.

Data Collection

Data collection was divided into three phases, as follows.

Phase 1: Situation analysis and model development (March 2025)

The researcher reviewed the relevant literature and invited the multidisciplinary team of Ban Nonrang SHPH (5 persons) and subdistrict network partners (3 persons) to form the research team. The situation and problems in caring for pregnant women were analyzed through focus group discussion together with antenatal registry data and the Java Health Center Information System (JHCIS), and content analysis was used to identify problems and needs. The research team

then jointly designed the prototype NONRANG Model, which was submitted to three experts to evaluate its appropriateness using the Index of Item-Objective Congruence (IOC) and was revised before use in cycle 1. Hb, Hct, and MCV were measured with an automated hematology analyzer at Khon Kaen Hospital.

Phase 2: Cycle 1, model implementation and follow-up (March–April 2025)

Conducted according to PAOR as follows.

1) Plan: The multidisciplinary team and network partners jointly formulated an individual care plan for each of the six pregnant women, based on Hb, Hct, and body weight measured before implementation (week 0), and defined the roles of each profession and network partner.

2) Act: The model was implemented, comprising assessment of self-care deficits, individual education and skills training, scheduled home visits, family training, referral coordination among the multidisciplinary team, and telephone follow-up. All pregnant women also received iron supplements and prenatal vitamins according to the antenatal care standard.

3) Observe: Hb, Hct, body weight on the Vallop Curve, and self-care behavior were recorded, together with problems and obstacles encountered.

4) Reflect: The research team held reflection meetings and conducted a strengths, weaknesses, opportunities, and threats (SWOT) analysis to improve the model for cycle 2.

Phase 3: Cycle 2, model refinement and summative evaluation (April–May 2025)

Conducted according to PAOR, building on lessons learned from cycle 1.

1) Plan: The model and individual care plans were reviewed and revised in line with changes in each pregnant woman's clinical values and behavior.

2) Act: The revised model was implemented continuously, emphasizing skill development of pregnant women and families in areas that remained deficient, and intensifying coordination with network partners and VHVs.

3) Observe: Hb, Hct, body weight on the Vallop Curve, and self-care behavior were assessed at the end of cycle 2, and satisfaction data were collected from the pregnant women and their families.

4) Reflect: The research team summarized results across the two cycles, compared outcomes before and after the model, finalized the NONRANG Model, and disseminated it as a practice guideline for SHPHs in the area.

Data Analysis

Qualitative data were analyzed by content analysis, and trustworthiness was ensured through triangulation, member checking, and an audit trail.[19]

Quantitative data were analyzed using descriptive statistics, namely frequency, percentage, mean ($\bar{x}$), and standard deviation (S.D.). For comparison of clinical values and self-care behavior scores before and after the model, the normality of the differences was tested with the Shapiro-Wilk test, and the paired t-test was

used when assumptions were met, while the exact Wilcoxon signed-rank test was used when they were not, because the sample comprised only six women. Effect size (Cohen's dz) and the 95% confidence interval of the mean difference were reported. The significance level was set at .05, with Hb as the primary outcome and the other outcomes treated as exploratory; when four outcomes were considered simultaneously, the significance level was adjusted by the Bonferroni method to .0125. Proportions were reported with 95% confidence intervals using the Clopper-Pearson method.

Research Ethics

The researcher protected the rights of participants by explaining the objectives and procedures of the study, and the pregnant women and research team members signed informed consent forms. Data were kept confidential and results were presented in aggregate, and participants had the right to withdraw from the study at any time without any effect on their health services. Because the researcher is a regular service provider at the SHPH, it was clarified that the decision to participate or withdraw would not affect entitlement to services, and all pregnant women received care according to the antenatal care standard. [Specify the ethics committee, approval number, and approval date]

Results

1. General characteristics and baseline health status of the participants

1.1 Personal information

The research team comprised 5 members of the multidisciplinary team of Ban Nonrang SHPH and 3 subdistrict network partners, totaling 8 persons (100.00% of the target group). The six pregnant women with iron deficiency anemia and underweight were all primigravidas (100.00%), with a mean age of 21.33±2.16 years; four (66.67%) had completed upper secondary education, five (83.33%) worked as hired laborers or farmers, and the mean pre-pregnancy BMI was 17.84±0.62 kg/m².

1.2 Baseline health status before implementation of the model

Before implementation, the pregnant women had a mean hemoglobin of 9.80±0.42 g/dL, a mean hematocrit of 30.00±1.26%, a mean MCV of 78.90±3.10 fL, and a mean self-care behavior score of 51.67±5.84, which was at the moderate level.

1.3 Situation and problems in the care of pregnant women with anemia and underweight

Focus group discussions together with antenatal registry data and JHCIS identified four main problems: 1) pregnant women ate insufficient iron-rich foods and took prenatal supplements irregularly; 2) education in the antenatal clinic was delivered in groups and did not match individual self-care deficits; 3) family involvement in care was low; and 4) follow-up of

pregnant women and coordination between the multidisciplinary team and VHVs were not systematic.

2. Care model for pregnant women with iron deficiency anemia and underweight

2.1 Structure and components of the model

The model developed, named the NONRANG Model, comprises seven components: N (Nutritional Assessment), assessment of nutritional and iron status; O (Orem-based Care Plan), a care plan based on Orem's theory; N (Nursing Activities), individualized nursing activities; R (Relatives Involvement), family involvement; A (Active Follow-up), proactive home-visit follow-up; N (Network Coordination), coordination of community networks and VHVs; and G (Goal Evaluation), outcome evaluation against goals, as shown in Table 1.

2.2 Implementation outcomes across cycles

All 8 members of the multidisciplinary team and network partners and all 6 pregnant women (100.00%) completed the research process. Every pregnant woman attended all scheduled antenatal visits throughout the study period. The rate of planned home visits increased from 83.33% (5 of 6 women; 95% CI 35.88-99.58) in cycle 1 to 100.00% (6 of 6 women; 95% CI 54.07-100.00) in cycle 2. In the cycle 1 SWOT reflection, the strengths were the readiness of the multidisciplinary team and VHVs; the weaknesses were workload and the harvest season; the opportunities were the subdistrict network and the LINE group; and the threats were the waiting time for laboratory results. The research team therefore adjusted each woman's care plan to her clinical values and behavior, emphasized skill development of pregnant women and families in areas that remained deficient, and intensified coordination with network partners and VHVs.

2.3 Difficulties and solutions

Five difficulties were encountered during implementation, with the following solutions: 1) coordination of the multidisciplinary team and network partners, especially during the harvest season when VHVs and families had heavy farm workloads, solved by establishing a coordination working group, preparing an advance calendar, creating a LINE group for VHVs, and arranging appointments before home visits; 2) clinical data collection from pregnant women with limited time who had to wait for laboratory results, solved by arranging laboratory appointments in advance with Khon Kaen Hospital; 3) developing the instruments and conducting two cycles within 3 months, solved by establishing a sub-working group for instrument development and holding reflection meetings every 2 weeks; 4) staff workload, solved by integrating activities into routine antenatal clinic work; and 5) attitudes toward change, solved by presenting positive results from the first pregnant woman to build the team's confidence.

3. Effects of the model on appropriateness, clinical values, self-care behavior, and satisfaction

3.1 Appropriateness of the model

Three experts rated the overall appropriateness of the NONRANG Model at the highest level (4.48±0.36). The highest-rated aspect was the suitability of the nursing activities for the Isan community context (4.56±0.28).

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3.2 Clinical values and self-care behavior

After implementation of the model, mean hemoglobin increased by 1.02 g/dL (from 9.80±0.42 to 10.82±0.54; 95% CI 0.50-1.54, t = 5.09, df = 5, p = .004, Cohen's dz = 2.08). Hematocrit increased from 30.00±1.26% to 34.67±1.62% (95% CI 3.12-6.22, p < .001), and MCV increased from 78.90±3.10 to 83.20±3.40 fL (95% CI 0.88-7.72, p = .023, which did not meet the Bonferroni threshold of .0125 and was therefore considered an exploratory result). All pregnant women (6 of 6; 100.00%; 95% CI 54.07-100.00) had weight gain within the green zone of the Vallop Curve nutrition chart by week 8 of implementation. Self-care behavior scores increased by 26.75 points (95% CI 21.25-32.25, t = 12.51, p < .001, Cohen's dz = 5.11), from the moderate level to the good level, with the three most improved aspects being consumption of iron-rich foods, regular intake of prenatal supplements, and rest and general health care, as shown in Table 2.

3.3 Satisfaction with the model

The six pregnant women and 6 family members reported overall satisfaction with the NONRANG Model at the highest level (4.49±0.41), with every aspect also at the highest level. The highest-rated aspect was staff knowledge and skills (4.58±0.36), followed by the care process and home visits (4.52±0.38), care outcomes (4.46±0.42), and communication and information provision (4.41±0.44), respectively, as shown in Table 3.

3.4 Qualitative findings

The NONRANG Model arose from the participation of the multidisciplinary team and network partners of Sawathi Subdistrict. The research team reported that the model's name, which echoes the name of Ban Nonrang village, created pride and a sense of ownership among the community and practitioners. From the reflections, the multidisciplinary team and network partners gained knowledge and confidence in their roles, and a collaborative network formed among professional nurses, public health officers, VHVs, and families. Husbands and families reported greater confidence in supporting the pregnant women.

Table 1 Components and activities of the NONRANG Model for the care of pregnant women

Component	Main activities	Responsible persons/tools	Rationale
N (Nutritional Assessment): assessment of nutritional and iron status	Assess Hb, Hct, MCV, body weight, and pre-pregnancy BMI; monitor body weight with the Vallop Curve; and assess dietary behavior regarding iron-rich foods and prenatal supplements	Professional nurse / clinical record form, Vallop Curve chart	Screens and monitors anemia and nutritional status in line with quality antenatal care guidelines[6]

Component	Main activities	Responsible persons/tools	Rationale
O (Orem-based Care Plan): care plan based on Orem's theory	Assess self-care deficits and prepare an individual care plan from clinical values and body weight, defining the roles of the multidisciplinary team and network partners	Multidisciplinary team / care plan	Tailors assistance to the self-care deficits of each pregnant woman[9,10]
N (Nursing Activities): individualized nursing activities	Provide individual education and skills training on choosing iron-rich foods from local ingredients, regular intake of prenatal supplements, and rest	Professional nurse / nutrition handbook	Strengthens self-care knowledge and skills through the supportive-educative nursing system[9,11]
R (Relatives Involvement): family involvement	Educate and train the husband and family to prepare iron-rich meals, remind the woman to take supplements, observe abnormal symptoms, and bring her to scheduled antenatal visits	Professional nurse, family / family handbook	Uses the family as a care partner according to the family-centered care concept[12,13]
A (Active Follow-up): proactive home-visit follow-up	Conduct scheduled home visits, follow up by telephone and LINE group, and record problems and obstacles encountered	Professional nurse, VHVs / operations record form	Provides feedback and prompts to sustain behavior[20]
N (Network Coordination): coordination of community networks and VHVs	Coordinate subdistrict network partners and VHVs to follow up pregnant women weekly, arrange appointments before home visits, and coordinate laboratory testing and referral among the multidisciplinary team	VHVs, subdistrict network partners / LINE group, operations calendar	Builds social support and continuity of care in the community
G (Goal Evaluation): outcome evaluation against goals	Evaluate Hb, Hct, MCV, body weight on the Vallop Curve, self-care behavior, and satisfaction; hold joint reflection meetings every 2 weeks; and revise the model according to the PDCA cycle	Research team / reflection record form, evaluation forms	Monitors outcomes and enables continuous improvement through the PDCA quality cycle[14]

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Table 2 Comparison of clinical values and self-care behavior scores before and after implementation of the model (n = 6)

Indicator	Before ($\bar{x}$±S.D.)	After ($\bar{x}$±S.D.)	Mean difference (95% CI)	t	p
Hemoglobin (g/dL)	9.80±0.42	10.82±0.54	+1.02 (0.50-1.54)	5.09	.004*
Hematocrit (%)	30.00±1.26	34.67±1.62	+4.67 (3.12-6.22)	7.76	<.001*
MCV (fL)	78.90±3.10	83.20±3.40	+4.30 (0.88-7.72)	3.23	.023*
Self-care behavior score	51.67±5.84	78.42±4.28	+26.75 (21.25-32.25)	12.51	<.001*

Note: *Statistically significant at the .05 level

Table 3 Satisfaction of pregnant women and families with the NONRANG Model (n = 12)

Satisfaction aspect	$\bar{x}$	S.D.	Level
Staff knowledge and skills	4.58	0.36	Highest
Care process and home visits	4.52	0.38	Highest
Care outcomes	4.46	0.42	Highest
Communication and information provision	4.41	0.44	Highest
Overall	**4.49**	**0.41**	**Highest**

Discussion

All pregnant women in this study were primigravidas with a mean age of 21.33 years and a mean pre-pregnancy BMI of 17.84 kg/m², below the 18.50 threshold, and a mean hemoglobin of 9.80 g/dL, below the WHO diagnostic criteria,[1,2] together with a mean MCV of 78.90 fL, which supports iron deficiency anemia. However, a low MCV can also occur in thalassemia,[18] and no serum ferritin was available for confirmation. These findings correspond to the reported risk factors, namely poor pre-pregnancy nutritional status and irregular use of prenatal supplements,[5] as well as underweight, which increases the risk of fetal growth restriction.[6] In addition, self-care behavior scores before implementation were at the moderate level, indicating gaps in self-care that nurses should address before complications arise for mother and infant.

The NONRANG Model was rated at the highest level of appropriateness, possibly because it was developed through an action research process in which the multidisciplinary team and network partners participated from the problem analysis stage, and because Orem's theory served as the basis for assessing self-care deficits and designing individualized activities.[9,10] The nutrition activities used local ingredients and therefore suited the way of life of Isan communities, as reflected in the context-suitability aspect receiving the highest mean

score. Involving husbands and families is consistent with studies finding that family support improves self-care behavior and raises hemoglobin levels,[12,21] and with the family-centered care concept.[13] Conducting two PDCA cycles allowed the team to apply lessons from cycle 1 to improve the model, which may be related to the increase in planned home visits from 83.33% to 100.00%, similar to the improvement of antenatal care quality with the PDCA cycle at SHPHs that increased attendance at scheduled visits.[15]

After implementation, hemoglobin, hematocrit, and MCV increased (Hb and Hct met the adjusted significance threshold, while MCV was an exploratory result). All pregnant women had body weight within the green zone of the Vallop Curve, and self-care behavior scores rose from the moderate to the good level, particularly in consuming iron-rich foods and taking prenatal supplements regularly. These results are similar to applications of Orem's self-care theory in pregnant women with anemia[11] and to health behavior modification programs consisting of education, demonstration, follow-up, and encouragement,[20] which rely on self-efficacy as the driving force.[22] The weight gain meeting the criteria is in line with individualized nutrition education combined with continuous weight monitoring.[23] In addition, multichannel follow-up through home visits, telephone, and the LINE group, with VHVs following up weekly, may have helped pregnant women adhere to their care plans continuously. However, the mean hemoglobin after implementation (10.82 g/dL) remained slightly below the 11.00 g/dL threshold, with approximately 2 of 6 pregnant women (33.33%; 95% CI 4.33-77.72) having Hb of 11.00 or above; follow-up and care should therefore continue into the postpartum period.

Pregnant women and families were satisfied with the model at the highest level, especially with staff knowledge and skills, similar to holistic care of pregnant women in SHPH antenatal clinics that produced high satisfaction and regular attendance at scheduled visits,[24] and to the systematic implementation of the Ministry of Public Health guideline for the care of pregnant women, which enabled earlier detection of anemia.[25]

The limitations of this study were as follows: 1) statistical, in that only six pregnant women were studied, so statistical power was low, confidence intervals were wide, and the lowest possible p-value of the exact test was .031, so results should be interpreted with caution; 2) design, in that there was no control group and follow-up was short, at 3 months, and the increase in hemoglobin may have resulted from iron supplementation under the antenatal care standard, advancing gestational age, or regression to the mean; 3) serum ferritin was not measured and thalassemia was not screened in every woman, so iron deficiency could not be fully confirmed; 4) the researcher was both practitioner and evaluator, so observer bias may have occurred even though laboratory values were the primary outcome; and 5) the study was conducted at a single SHPH, so causality of the model cannot be concluded and the results cannot be generalized to other areas.

Conclusion

The study achieved its objectives as follows. Objective 1: the situation and problems comprised problems with attending services and missed appointments. Objective 2: the NONRANG Model was developed, comprising seven components, by applying Orem's Self-Care Deficit Nursing Theory together with two PDCA cycles. Objective 3: experts rated its appropriateness at the highest level (4.48±0.36). After implementation, the six pregnant women had increased hemoglobin from 9.80±0.42 to 10.82±0.54 g/dL (p = .004), increased hematocrit, body weight within the green zone of the Vallop Curve in every case, self-care behavior scores rising from the moderate to the good level, and satisfaction at the highest level (4.49±0.41). However, because the sample was small and there was no control group, it can only be concluded that the model is appropriate and that changes in a favorable direction were observed; effectiveness cannot yet be concluded.

Recommendations

1. Recommendations for application of the findings

1.1 Ban Nonrang SHPH may pilot the NONRANG Model and its handbook as a draft practice guideline for the care of pregnant women with anemia and underweight, integrating it into routine antenatal clinic work.

1.2 Other SHPHs in Mueang Khon Kaen District and under the Khon Kaen Provincial Administrative Organization with similar contexts may apply the model; scale-up should await evidence from studies with a comparison group, and the nutrition activities should be adapted to local ingredients.

1.3 The Khon Kaen Provincial Administrative Organization and the Khon Kaen Provincial Public Health Office may consider adopting the anemia rate in pregnant women and the rate of newborns weighing less than 2,500 g as SHPH indicators, supporting budgets for home visits, laboratory testing, and locally specific nutrition materials, and continuously developing the competencies of personnel and VHVs.

2. Recommendations for future research

Future studies should use a quasi-experimental design with a comparison group across multiple SHPHs, or a cluster randomized pilot trial, comparing the NONRANG Model with usual care, with the sample size calculated from the effect size of Hb; follow-up should extend at least 6 months postpartum to assess the sustainability of self-care behavior, infant health, and anemia in the next pregnancy; and studies should be conducted in diverse settings and among pregnant women with different characteristics, such as severe anemia, multiple pregnancy, and comorbidities.

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ORIGINAL ARTICLE

Development of a Hemoglobin A1c (HbA1c) Testing Service Model in the Medical Laboratory for Diabetes Care at Huaimek Hospital, Kalasin Province

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Abstract

This research and development study aimed to develop a hemoglobin A1c (HbA1c) testing service model in the medical laboratory for diabetes care and to compare outcomes between a model group and a usual-care group at Huaimek Hospital, Kalasin Province. It was conducted from October 2025 to June 2026 in three phases: situation analysis, model development, and a 12-week trial using a two-group pretest-posttest quasi-experimental design. Sixty patients with type 2 diabetes were allocated, by clinic day rather than individual randomization, to an experimental group and a control group of 30 each. Data were analyzed using descriptive statistics, paired t-test, independent t-test, and chi-square test, with post-trial HbA1c as the primary outcome. The model had five components: patient preparation and appointment, laboratory analysis with quality control, same-day result reporting, result interpretation and counseling by a multidisciplinary team, and follow-up. The median result waiting time was 2.4 hours compared with 7 days in historical data. After the trial, the experimental group had a lower mean HbA1c than the control group (7.64±1.06 vs 8.87±1.35 %; mean difference -1.23, 95% CI -1.86 to -0.60; t = -3.93, df = 58, p < .001), a higher knowledge score (12.87±1.46 vs 8.93±1.98; mean difference 3.94, 95% CI 3.04-4.84; t = 8.77, df = 58, p < .001), and a higher proportion achieving HbA1c <7.00% (12/30 vs 4/30; χ^2 = 5.45, df = 1, p = .020; Fisher p = .039).

Keywords: model development, hemoglobin A1c, medical laboratory, diabetes mellitus

Introduction

Diabetes is a major global public health problem. According to the International Diabetes Federation (IDF), in 2024 an estimated 589 million adults aged 20-79 years worldwide

had diabetes, about 1 in 9, and the number is projected to rise to 853 million by 2050.[1] In Thailand, an estimated 6.36 million adults have diabetes, with an age-adjusted prevalence of 10.2%, and about 33.3% remain undiagnosed.[1] Hemoglobin A1c (HbA1c) reflects average blood glucose over the preceding 2-3 months and is therefore the principal indicator for monitoring disease control. The American Diabetes Association (ADA) guidelines recommend testing at least twice a year in patients who are meeting treatment goals, and every 3 months in those whose therapy has changed or who are not yet meeting goals; the general target for non-pregnant adults is HbA1c <7.00%.[2] Each 1% reduction in HbA1c is associated with an approximately 37% reduction in microvascular complications.[3]

In Kalasin Province, about 49,000 patients with diabetes were registered in the Health Data Center in 2024, and only about 31% achieved glycemic targets,[4] while the Thai clinical practice guideline for diabetes sets a target of HbA1c <7.00% for most patients.[5] Huaimek Hospital is a 60-bed community hospital. In fiscal year 2025 it had 1,846 registered patients with type 2 diabetes, but only 701 (37.97%) had at least one HbA1c test. Because the hospital had no HbA1c analyzer, samples had to be sent to an external laboratory, which delayed results, with a median waiting time of 7 days. Most patients therefore did not know their results on the day of the physician visit.

The medical laboratory plays an important role in diabetes care because HbA1c results must be accurate, precise, and comparable according to the calibration standards of the National Glycohemoglobin Standardization Program (NGSP).[6,7] In addition, most laboratory errors occur in the pre-analytical and post-analytical phases, which involve patient preparation, sample collection and transport, and communication of results.[8] There is evidence that having HbA1c results available at the time of the physician visit enables physicians to adjust treatment more appropriately.[9,10] However, previous studies have focused on point-of-care testing or large hospital settings, and evidence remains limited on developing a model that links analytical quality, result reporting, and counseling in the laboratory of a community hospital.

The researcher therefore developed an HbA1c testing model in the medical laboratory for diabetes care at Huaimek Hospital, Kalasin Province, and compared the outcomes of the model with usual service. The findings may serve as a guide for laboratories and health teams in other community hospitals to adapt, so that patients receive accurate, timely test results and achieve better blood glucose control.

Research Objectives

1) To study the situation and problems of HbA1c testing in patients with diabetes at Huaimek Hospital
2) To develop an HbA1c testing model in the medical laboratory for diabetes care

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3) To compare outcomes after implementation of the model between the experimental group and the control group, with HbA1c as the primary outcome and knowledge score and the proportion of patients with HbA1c <7.00% as secondary outcomes

Methods

This research and development (R&D) study was conducted at Huaimek Hospital, Kalasin Province, from October 2025 to June 2026 in three phases. Phase 1, situation analysis (October-November 2025), involved a review of retrospective data for fiscal year 2025 and focus group discussions with stakeholders. Phase 2, model development (December 2025), included an appropriateness review by experts. Phase 3, model trial (January-March 2026), used a two-group pretest-posttest quasi-experimental design with non-individual allocation to groups.[11] The model lasted 12 weeks, and data were analyzed between April and June 2026.

Population and Sample

The Phase 1 population comprised 18 key informants involved in HbA1c testing (2 physicians, 5 nurses, 3 medical technologists, 2 pharmacists, 4 patients with diabetes, and 2 administrators). The Phase 3 population comprised 1,846 patients with type 2 diabetes registered at the noncommunicable disease clinic of Huaimek Hospital as of October 2025, of whom 134 met the eligibility criteria on screening.

Sample size was calculated using G*Power for an independent t-test, with an effect size (Cohen's d) of 0.80,[12] a significance level of .05, and power of 0.80, giving 26 per group. Allowing for 15% attrition, 30 per group, or 60 in total, were used. Participants were selected purposively according to the criteria and then assigned to groups by clinic day to reduce contamination of activities between groups. The service days were drawn by lot to designate the experimental group (Tuesday) and the control group (Thursday). This allocation was by cluster, with two clusters (service days), rather than individual randomization, and the effect of clustering was not adjusted for in the sample size calculation.[13]

Inclusion criteria were: 1) age 30-75 years; 2) diagnosed with type 2 diabetes for at least 1 year; 3) most recent HbA1c of 7.00% or higher; 4) able to communicate in Thai and to use a telephone or the LINE application; and 5) willing to provide consent to participate in the research.

Exclusion criteria were: 1) severe anemia, hemoglobin variants (for example, HbE, which is common in northeastern Thailand and can interfere with measurement by some methods),[14] or blood transfusion within the previous 3 months, all of which may interfere with HbA1c interpretation; 2) stage 5 chronic kidney disease or receiving dialysis; 3) pregnancy; 4) severe acute complications during

the study; and 5) missing more than one follow-up or withdrawal from the study.

Research Instruments

The research instruments comprised: 1) the intervention instrument, namely the HbA1c testing model in the medical laboratory, consisting of a manual and standard operating procedures (SOP), a service flowchart, a result report showing the HbA1c trend, a chart converting HbA1c to estimated average glucose (eAG),[15] and educational media.

2) Data collection instruments: (1) a general information record form; (2) a 15-item knowledge test on HbA1c and self-care, scored 1 for a correct answer and 0 for an incorrect answer (maximum score 15); (3) HbA1c testing using an NGSP-certified analyzer with internal quality control at 2 concentration levels on every testing day and participation in external quality assessment;[6,7] the external laboratory that tested the control group samples used the analyzer and measurement principle; and (4) a result turnaround time (TAT) record form. Content validity was examined by 3 experts, and the index of item-objective congruence (IOC)[16] was 0.67-1.00 for the knowledge test and 0.80-1.00 for the model. The knowledge test was piloted with 30 patients with diabetes who were not part of the sample, giving a KR-20 reliability of 0.82.

Data Collection

In Phase 1, the researcher collected data from electronic medical records and focus group discussions. In Phase 3, the experimental group received the developed model for 12 weeks, while the control group received usual service, that is, samples were sent to an NGSP-certified external laboratory and patients learned their results at the next scheduled visit. Both groups had blood drawn for HbA1c and completed the knowledge test in week 1 (pre-trial) and week 12 (post-trial), administered by 2 research assistants trained in the use of the instruments. The researcher supervised the service providers for both groups, prevented contamination between groups, and provided usual HbA1c education to the control group.

Data Analysis

Statistical software was used to analyze general data with descriptive statistics, namely frequency, percentage, mean, standard deviation, median, and interquartile range. Normality of the data and of the differences was checked using the Shapiro-Wilk test, and equality of variances using Levene's test. The primary outcome was post-trial HbA1c, compared between groups using the independent t-test (Welch's t-test when variances were unequal), with an ANCOVA adjusted for pre-trial HbA1c to reduce the effect of baseline differences and regression to the mean.[17,18] Within-group pre-post means were compared using the paired t-test (Wilcoxon signed-rank test when assumptions were not met). Proportions were compared using the chi-square test, with Fisher's exact test as a sensitivity analysis. Results are reported as differences with 95% confidence intervals (95% CI) and effect sizes (Cohen's d and dz). The two

secondary outcomes (knowledge score and the proportion with HbA1c <7.00%) were tested at a Bonferroni-adjusted significance level of .025, while the primary outcome was tested at .05.

Research Ethics

[Specify the ethics committee, approval number, and approval date] In this study, the researcher explained the objectives and procedures to all participants, who signed informed consent forms before participating. Data were kept confidential and presented in aggregate, and participants were informed of their right to withdraw from the study without any effect on their treatment. Patients in the control group received standard usual care.

Results

Situation and Problems of HbA1c Testing in Patients with Diabetes at Huaimek Hospital

HbA1c testing situation

Retrospective data for fiscal year 2025 showed 1,846 registered patients with type 2 diabetes, of whom 701 (37.97%) had at least one HbA1c test. Among those tested, 187 (26.68%) had HbA1c <7.00%. All samples were sent to an external laboratory, with a median waiting time of 7 days (interquartile range 5-10 days). A total of 638 patients (91.01%) did not receive their results on the day of the physician visit, and 27 samples (3.85%) had to be recollected because of inappropriate collection or transport.

Problems and needs

The focus group discussions with 18 participants identified four problems and needs: 1) delayed results that came too late to inform treatment adjustment on the day of the physician visit; 2) no system for preparing patients and scheduling HbA1c tests in advance; 3) patients' lack of knowledge and understanding of what HbA1c values mean; and 4) no internal quality control system for HbA1c testing in the hospital and no guideline for communicating results between the laboratory and the clinic.

Development of the HbA1c Testing Model in the Medical Laboratory for Diabetes Care

The developed HbA1c testing model

Based on the situation analysis, the researcher and a multidisciplinary team developed a model with 5 components: 1) preparing patients and scheduling tests in advance of the physician visit; 2) analyzing HbA1c in the hospital laboratory using an NGSP-certified analyzer with internal and external quality control; 3) reporting results within the same day through the hospital information system; 4) individual result interpretation and counseling by the medical technologist together with the physician, nurse, and pharmacist; and 5) follow-up by telephone and a LINE group. The model was reviewed by 3 experts, with an IOC of 0.80-1.00, and activities ran throughout 12 weeks, as shown in Table 1.

Table 1 Activities of the HbA1 c testing model in the medical laboratory for diabetes care over 12 weeks

Week	Activity/Content	Tools Used	Duration	Rationale
1	Orientation, project briefing, first blood draw for HbA1c, and pre-trial knowledge test	Knowledge test, general information record form, advance appointment slip	60 minutes	Prepare patients and collect samples correctly to reduce pre-analytical errors[8]
1	Analyze HbA1c in the hospital laboratory and report results within the same day	NGSP-certified HbA1c analyzer, 2-level quality control material, hospital information system	2-4 hours	Standard-comparable, timely results allow the physician to adjust treatment at the same visit[6,7,10]
1	Individual result interpretation and counseling; set an HbA1c target together with the patient	Result report showing HbA1c trend, chart converting values to eAG	30 minutes	Immediate HbA1c feedback improves glycemic control,[9] and conversion to average glucose makes the result easier for patients to understand[15]
2	Education on HbA1c, control targets, and self-care in small groups by the multidisciplinary team	Slides, leaflets, video clips	45 minutes	Increase knowledge and understanding of what HbA1c values mean, which is the basis of self-care
4 and 8	Telephone and LINE group follow-up reviewing targets, medication use, diet, and exercise	Follow-up record form, LINE group	15 minutes/ session	Continuous follow-up between testing rounds; the ADA guidelines recommend testing every 3 months in patients not yet at target[2]
12	Second blood draw for HbA1c, same-day result reporting, post-trial knowledge test, and summary of results with the patient	HbA1c analyzer, knowledge test	60 minutes	HbA1c reflects average glucose over 2-3 months, so outcomes were assessed at 12 weeks[2,6]

Note: NGSP = National Glycohemoglobin Standardization Program; eAG = estimated average glucose; ADA = American Diabetes Association

Quality and process outcomes of the model

During the trial, the laboratory tested 60 HbA1c samples for the experimental group (30 patients, 2 tests each). Same-day reporting was achieved for 100% (60 of 60 samples). The turnaround time from sample receipt to result reporting had a median of 2.4 hours (interquartile range 2.0-3.1 hours), compared with a median of 7 days in the retrospective data of the previous system (a descriptive comparison with no statistical testing). Internal quality control met the acceptance criteria in every run, and the between-day coefficient of variation (CV) was 1.84% and 1.62% at the low and high concentration levels, respectively. Two rounds of external quality assessment were within the acceptable range (within ±6.00% of the target value), and 1 sample (1.67%) had to be recollected, down from 3.85% in the previous system.

Effectiveness of the HbA1c Testing Model in the Medical Laboratory for Diabetes Care

General characteristics of the sample

The sample comprised 60 patients, 30 per group, all of whom completed the 12 weeks, with no exclusions or withdrawals. The experimental group had 21 women (70.00%) and the control group 20 (66.67%). Mean ages were 58.43±8.76 and 59.10±9.21 years, and mean durations of diabetes were 8.27±4.12 and 8.53±4.35 years, respectively. General characteristics of the two groups did not differ statistically (sex $\chi^2 = 0.08$, df = 1, p = .78; age t = 0.29, df = 58, p = .77; duration of diabetes t = 0.24, df = 58, p = .81).

Within-group comparison before and after the trial

After the 12-week trial, the experimental group's mean HbA1c decreased from 9.12±1.38 to 7.64±1.06 (difference -1.48, 95% CI -1.90 to -1.06; t = 7.19, df = 29, p < .001; Cohen's dz = 1.31), and the knowledge score increased from 8.43±2.01 to 12.87±1.46 points (difference 4.44, 95% CI 3.66-5.22; t = 11.58, df = 29, p < .001; dz = 2.11), both statistically significant. The control group showed no statistically significant change in either HbA1c (9.05±1.42 to 8.87±1.35; difference -0.18, 95% CI -0.58 to 0.22; t = 0.92, df = 29, p = .367; dz = 0.17) or knowledge score (8.50±2.10 to 8.93±1.98; difference 0.43, 95% CI -0.16 to 1.02; t = 1.49, df = 29, p = .148; dz = 0.27), as shown in Table 2.

Table 2 Comparison of mean HbA1c and knowledge scores before and after the trial, by group (paired t-test; n = 30 per group)

Variable	Group	Pre ($\bar{x}$±SD)	Post ($\bar{x}$±SD)	Difference (95% CI)	t (df = 29)	p
HbA1c (%)	Experimental	9.12±1.38	7.64±1.06	-1.48 (-1.90 to -1.06)	7.19	< .001*

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Variable	Group	Pre ($\bar{x}$±SD)	Post ($\bar{x}$±SD)	Difference (95% CI)	t (df = 29)	p
HbA1c (%)	Control	9.05±1.42	8.87±1.35	-0.18 (-0.58 to 0.22)	0.92	.367
Knowledge score (max 15)	Experimental	8.43±2.01	12.87±1.46	4.44 (3.66-5.22)	11.58	< .001*
Knowledge score (max 15)	Control	8.50±2.10	8.93±1.98	0.43 (-0.16 to 1.02)	1.49	.148

Note: *Statistically significant at the .05 level

Between-group comparison of the experimental and control groups

Before the trial, HbA1c (9.12±1.38 vs 9.05±1.42; t = 0.19, df = 58, p = .847) and knowledge scores (8.43±2.01 vs 8.50±2.10; t = -0.13, df = 58, p = .896) did not differ between the two groups. After the trial, the experimental group had a mean HbA1c 1.23 percentage points lower than the control group (95% CI -1.86 to -0.60; t = -3.93, df = 58, p < .001; Cohen's d = -1.01) and a knowledge score 3.94 points higher (95% CI 3.04-4.84; t = 8.77, df = 58, p < .001; d = 2.27). In the ANCOVA adjusting for pre-trial HbA1c, the adjusted mean difference in HbA1c was -1.21 (95% CI -1.83 to -0.59; p < .001), as shown in Table 3.

Table 3 Comparison of mean HbA1c and knowledge scores between the experimental and control groups (independent t-test; n = 30 per group)

Variable	Period	Experimental ($\bar{x}$±SD)	Control ($\bar{x}$±SD)	Difference (95% CI)	t	p
HbA1c (%)	Pre	9.12±1.38	9.05±1.42	0.07 (-0.65 to 0.79)	0.19	.847
HbA1c (%)	Post	7.64±1.06	8.87±1.35	-1.23 (-1.86 to -0.60)	-3.93	< .001*
HbA1c (%)	Post (ANCOVA)			-1.21 (-1.83 to -0.59)	-	< .001*
Knowledge score (max 15)	Pre	8.43±2.01	8.50±2.10	-0.07 (-1.13 to 0.99)	-0.13	.896
Knowledge score (max 15)	Post	12.87±1.46	8.93±1.98	3.94 (3.04-4.84)	8.77	< .001*

Note: *Statistically significant at the .05 level, Bonferroni-adjusted

Proportion of patients achieving the glycemic target

After the trial, 12 patients (40.00%; 95% CI 22.70-59.40) in the experimental group had HbA1c <7.00%, higher than the 4 patients (13.33%; 95% CI 3.80-30.70) in the control group. The difference in

proportions was 26.67% (95% CI 5.30-48.00), a statistically significant difference (χ^2 = 5.45, df = 1, p = .020), as shown in Table 4.

Table 4 Comparison of the proportion of patients achieving the glycemic target after the trial between the experimental and control groups (n = 30 per group)

Glycemic control outcome	Experimental (n = 30) No. (%; 95% CI)	Control (n = 30) No. (%; 95% CI)	Difference in proportion (95% CI)	χ^2	p
HbA1c <7.00%	12 (40.00; 22.70-59.40)	4 (13.33; 3.80-30.70)	26.67 (5.30-48.00)	5.45	.020*
HbA1c ≥7.00%	18 (60.00)	26 (86.67)	-	-	-

Note: *Statistically significant at the .05 level, Bonferroni-adjusted

Discussion

The situation analysis found that HbA1c testing coverage among patients with diabetes was only 37.97% and that 91.01% of patients did not receive their results on the day of the physician visit because samples had to be sent to an external laboratory, which meant lost opportunities to adjust treatment. This is consistent with a study finding that having HbA1c results available at the time of the visit improves clinical decision-making.[10] The developed model was therefore designed to cover the pre-analytical, analytical, and post-analytical phases, because most laboratory errors occur outside the analytical step,[8] and it used an analyzer comparable to the NGSP standard to ensure reliable results.[6,7] The model enabled same-day reporting for 100% of samples (median 2.4 hours versus a median of 7 days in the retrospective data, a descriptive comparison), reduced recollected samples to 1.67%, and met the quality control criteria in every run.

After the trial, the experimental group's HbA1c fell by 1.48 (from 9.12 to 7.64; 95% CI 1.06-1.90), whereas the control group's fell by only 0.18, which was not statistically significant. As a result, the experimental group's post-trial mean was 1.23 lower than that of the control group ($p < .001$), and a higher proportion reached the HbA1c <7.00% target (40.00% vs 13.33%; p = .020). This is consistent with Cagliero et al., who reported that immediate feedback of HbA1c values improved glycemic control,[9] which may be explained by the fact that when patients and physicians see the result on the same day, medication and behavior can be adjusted immediately. The observed reduction in HbA1c may be clinically important, because a 1% reduction in HbA1c is associated with a lower risk of microvascular complications.[3] In addition, the experimental group's knowledge score rose by 4.44 points (from 8.43 to 12.87), while the control group's changed by only 0.43 points, which may result from the individual result interpretation and the conversion to estimated average glucose (eAG), which made

the meaning of HbA1c easier for patients to understand.[15] However, all patients were enrolled with an HbA1c of 7.00% or higher, so regression to the mean may have occurred and may account for part of the decrease; but the control group, enrolled with the same criterion, fell by only 0.18, so the effect is likely limited.[18] Moreover, the model is a bundle of activities (laboratory testing, counseling, education, and follow-up), so it is not possible to separate which component produced the outcomes, and part of the increase in knowledge scores may be due to the experimental group receiving more direct education than the control group[19].

The limitations of this study were: 1) patients were not randomized individually but grouped by service day, which gives only 2 clusters, so the effect of the model cannot be separated from the effect of the service day, the service providers, or patient characteristics on each day, even though the baseline data of the two groups were similar;[13] 2) the control group's HbA1c was tested at an external laboratory, unlike the experimental group, and although both laboratories are NGSP-certified, measurement methods may differ, and some hemoglobin variants, such as HbE, may interfere with measurement differently depending on the method,[14] which could bias the difference between groups; 3) the research assistants may have known patients' group assignments, which could introduce measurement bias, and using the same knowledge test before and after may have led to recall effects; 4) the sample was small (30 per group) and the sample size was calculated from an effect size of 0.80; if the true effect size were 0.50, about 64 per group would be needed; 5) follow-up lasted only 12 weeks, which is the minimum period over which HbA1c reflects glucose levels; and 6) the study was conducted in a single community hospital, so caution is needed in generalizing the results to other contexts[19].

Conclusion

This study achieved its objectives, as follows. Objective 1: the situation analysis found that HbA1c testing covered only 37.97% of patients, the median waiting time was 7 days, and 91.01% of patients did not receive results on the day of the physician visit. Objective 2: a model with 5 components was developed that reported results within the same day for 100% of samples (median 2.4 hours). Objective 3: after the 12-week trial, the experimental group had a lower mean HbA1c, a higher knowledge score, and a higher proportion with HbA1c <7.00% than the control group. However, because participants were not randomized individually, the study can conclude only that the group that received the model had better outcomes; causal conclusions cannot be drawn.

Recommendations

Recommendations for application: Community hospitals in similar contexts may adapt the model, and wider rollout should await evidence from studies with comparison groups. Implementation should begin with developing procedures, selecting an NGSP-

certified analyzer, linking result reporting to the hospital information system, and training the multidisciplinary team.

Recommendations for future research: Future studies should use cluster-randomized or individually randomized designs with a control group (randomized controlled trial) across multiple hospitals, use the same HbA1c measurement method in both groups, blind data collectors, follow patients for at least 6-12 months, and assess economic cost-effectiveness.

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ORIGINAL ARTICLE

Development of a Risk Management Data Dashboard and Its Effects on Risk Data Utilization Competency of Risk Coordinators at Kalasin Hospital

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Abstract

This research and development (R&D) study, using a two-group pretest-posttest quasi-experimental design, aimed to develop a risk management data dashboard and compare the effects of its use at Kalasin Hospital. It was conducted from February to June 2025. Sixty risk coordinators and staff responsible for risk data were allocated by hospital unit to an experimental group and a control group of 30 each. The experimental group used the dashboard with a workshop and follow-up for 8 weeks, whereas the control group used the usual reporting process. Data were analyzed using paired t-test, independent t-test, and chi-square test. The dashboard had five main screens. Experts rated its appropriateness at the highest level (4.58±0.43), and users rated its usability at 82.50±8.12 points. After the intervention, the experimental group had higher knowledge scores than the control group (17.30±1.80 vs 13.10±2.28; mean difference 4.20, 95% CI 3.14-5.26; $p < .001$), higher competency scores (26.47±2.55 vs 20.87±3.38; mean difference 5.60, 95% CI 4.05-7.15; $p < .001$), and a higher proportion reporting incidents within 24 hours (26/30, 86.67% vs 18/30, 60.00%; χ^2 $p = .020$; Fisher $p = .039$). The dashboard group had better outcomes; however, allocation was by hospital unit in a single hospital, so randomized multi-hospital studies are needed.

Keywords: dashboard, risk management, incident data, patient safety

Introduction

Patient safety is a major global public health issue. The Institute of Medicine of the United States estimated that 44,000-98,000 people die each year in hospitals from medical errors.[1] The World Health Organization reported that in high-income countries about 1 in 10 patients is harmed while receiving hospital care, and that in low- and middle-income countries

about 134 million adverse events occur in hospitals each year, resulting in about 2.6 million deaths.[2] The Global Patient Safety Action Plan 2021-2030 emphasizes the use of data and learning to prevent avoidable harm.[3] Incident reporting systems are therefore a core tool of risk management, but their value depends on data analysis and timely feedback to practitioners.[4] In Thailand, the 5th edition of the Hospital and Healthcare Standards requires hospitals to have a risk and safety management system that uses incident data to learn and improve service quality.[5]

Kalasin Hospital is a provincial general hospital under the Ministry of Public Health, with approximately 600 beds and more than 40 service and support units. Incident reporting data for the previous 12 months (October 2023-September 2024) showed 3,248 incidents, of which 62.41% were clinical and 37.59% were non-clinical, and 7.51% were severity level E-I. However, the data were scattered across several sources, including paper forms, Excel files, and the system database. Compiling the monthly report took an average of 4.50 working days, so executives and units received information late and follow-up of corrective actions was not continuous.

A dashboard displays the most important information needed to achieve one or more objectives on a single screen, allowing the overall picture to be monitored at a glance.[6] A literature review found that dashboards can support improvements in the quality of patient care, but evidence on outcomes remains limited and inconsistent across studies.[7,8] Meanwhile, user acceptance of technology, which is related to perceived usefulness and perceived ease of use, is a determinant of the success of information systems,[9] and the design science research process supports systematic technology development.[10]

However, the knowledge gap is that few studies have developed risk management dashboards for provincial hospitals in Thailand and evaluated both usability and outcomes on practitioners' data use together.

Therefore, the researchers developed a dashboard technology to manage risk management data at Kalasin Hospital, consolidating incident data in one place, presenting it as easy-to-understand visuals, and updating data automatically, and studied its effects on knowledge, risk data analysis and utilization competency, and incident reporting by practitioners. The results are expected to benefit the risk management committee in decision-making, trend monitoring, and prioritizing incident prevention, and to serve as a model for other hospitals.

The research hypothesis was that, after the 8 - week intervention, the experimental group would have higher knowledge scores, higher risk data analysis and utilization competency scores, and a higher proportion reporting incidents within 24 hours than the control group.

The research framework used the design science research process as the framework for developing the dashboard[10] and the technology acceptance concept (perceived usefulness and perceived ease of use)[9] as a guide for designing

the training and evaluating usability. The independent variable was the dashboard together with training and follow-up; the dependent variables were knowledge, risk data analysis and utilization competency, and incident reporting within 24 hours; and the variables to be controlled were profession, experience, and type of unit.

Research Objectives

1) To study the situation and risk management information needs of practitioners at Kalasin Hospital
2) To develop a dashboard technology for managing risk management data and to evaluate its quality and usability
3) To compare knowledge and risk data analysis and utilization competency (before and after) and the proportion of incidents reported within 24 hours (after the intervention) between the experimental and control groups

Methods

This research and development (R&D) study[11] was conducted at Kalasin Hospital from February to June 2025 in three phases.

Phase 1: Situation and needs analysis (weeks 1-2). Past incident data were reviewed and a focus group discussion was held with 12 stakeholders, selected by purposive sampling from executives, the risk management committee, risk coordinators, and healthcare personnel. The researcher moderated the discussion and a research assistant recorded it. Qualitative data were analyzed using content analysis.

Phase 2: Dashboard development and quality evaluation (weeks 3-8) followed the six steps of the design science research process:[10] (1) identify the problem and motivation, (2) define the objectives of the solution, (3) design and develop, (4) demonstrate, (5) evaluate, and (6) communicate the results. The dashboard was evaluated by 5 experts and tried out with 10 users. The experts comprised 2 in risk management and quality, 2 in health informatics, and 1 in statistics and research methodology. The 10 users were not part of the Phase 3 sample.

Phase 3: Dashboard trial (weeks 9-17) used a quasi-experimental design, comprising training and pre-intervention measurement in week 9 and 8 weeks of dashboard use by the experimental group (April-May 2025). Details are as follows.

Population and Sample

The population was 120 risk coordinators and staff responsible for unit-level risk data at Kalasin Hospital, from 48 units (30 clinical and 18 non-clinical) in fiscal year 2025. Of these, 108 met the inclusion criteria.

The sample of 60 participants was calculated using G*Power[12] for an independent t-test (two-tailed) with an effect size (Cohen's d) of 0.80,[13] a large effect according to Cohen's criteria, set from the expected effect of training combined with the dashboard and not based on a pilot study, a significance level of .05, and power of .80, giving 26 per group. Allowing for 15.00% attrition (26 × 1.15 = 29.90, rounded up to 30), each group comprised 30 participants.

Participants were selected by simple random sampling using a lottery from the list of those meeting the criteria, then assigned to the experimental and control groups by matching on unit type (clinical and non-clinical), with participants from the same unit placed in the same group. Thus the unit of allocation was the unit (cluster), so this was a quasi-experimental study, and the cluster effect was not adjusted for in the sample size calculation,[14] with 12 units per group. Allocation was done by lottery drawn by a research assistant not involved in the training, and group allocation was not concealed from participants or researchers, in order to reduce contamination within units. However, coordinators from different units in the same hospital might exchange information, so access to the dashboard was restricted for the control group by assigning individual permissions according to the experimental group list and checking the Power BI access log weekly.

Inclusion criteria were: 1) working at Kalasin Hospital for at least 1 year; 2) being a risk coordinator or having duties to report or analyze unit risk data; 3) being able to access the system using a computer or smartphone; and 4) being willing to participate and signing the consent form.

Exclusion criteria were: 1) study leave or continuous leave of more than 2 weeks during the intervention period; and 2) withdrawal from the study. Participants who attended fewer than 80.00% of the activities were not excluded but were recorded as adherence level and analyzed according to the assigned group (intention-to-treat).

Research Instruments

The research instruments comprised 1) intervention tools, namely a risk management dashboard developed with Microsoft Power BI and connected to the incident reporting database, a user manual, and a workshop plan. The accuracy of the data on the dashboard was verified against the source database by randomly checking 100 incidents, which showed 99.00% agreement. The February 2025 version of Power BI was used, and personal data were managed by not displaying patient or reporter names on the dashboard and by assigning role-based access.

2) Data collection tools, namely (1) a general information questionnaire; (2) a 20-item test of knowledge on risk management and data use; (3) a 10-item risk data analysis and utilization competency assessment, with a total score of 30, which was a self-assessment, where competency was defined as the ability to read and interpret risk data, analyze trends, prioritize, and use data for decision-making and work improvement; (4) a 10-item System Usability Scale (SUS), with total scores ranging from 0 to 100 (68.00 is the average and 70.00 is acceptable);[15] (5) an incident reporting record form; and (6) a 5-level dashboard quality assessment form for experts.

The instruments were checked for content validity by 5 experts (in risk management and quality, health informatics, measurement and evaluation, and statistics), yielding an Index of Item-Objective Congruence (IOC) of 0.80-1.00. They were tried out with 30 practitioners who were not in the sample, giving a KR-20 of 0.82 for the knowledge test (KR-20 in the main sample was 0.80, item difficulty 0.30-0.80, and

discrimination 0.20-0.60), a Cronbach's alpha of 0.88 for the competency assessment, and 0.90 for the SUS.

Data Collection

Data were collected by the researcher and 2 research assistants; the research assistants knew the group allocation and received training once, before data collection began, on identical data collection and briefing procedures for all groups. They explained the objectives and obtained consent, after which participants completed the general information questionnaire, knowledge test, and competency assessment before the intervention. The experimental group attended the workshop and used the dashboard for 8 weeks, while the control group used the usual monthly summary report without any replacement activity. The researcher taught using the same training plan and manual, used a checklist to monitor that the activities were carried out as planned, and only the 30 experimental-group participants attended the training. At the end of the intervention (first week of June 2025), the same tests and assessments were repeated, the experimental group additionally completed the SUS, and the researcher collected incident reporting times from the hospital database, counted from the time of the event to the time of entry into the system, and calculated the proportion of participants who reported at least 80.00% of the incidents for which they were responsible within 24 hours. The 80.00% cut-off was set to separate those who mostly reported on time from those who did not, and incidents occurring in weeks 10-17 of the intervention were counted. This indicator was not measured before the intervention.

Data Analysis

Descriptive statistics were frequencies, percentages, means, and standard deviations, using IBM SPSS Statistics version 28 and R version 4.3 for the mixed-effects model. Normality was checked using the Shapiro-Wilk test and equality of variances using Levene's test. The primary outcome was the post-intervention competency score, and the secondary outcomes were the knowledge score and the proportion reporting within 24 hours. Pre-post scores within groups were compared using the paired t-test (Wilcoxon signed-rank test when assumptions were not met); between-group comparisons used the independent t-test (Welch's t-test or Mann-Whitney U test when assumptions were not met) and ANCOVA adjusting for pre-intervention scores.[16] Because groups were allocated by unit, a mixed-effects model with unit as a random effect should be used for analysis. Proportions were compared using the chi-square test and Fisher's exact test. Differences, 95% confidence intervals (95% CI), and effect sizes (Cohen's d and dz)[13] were reported. For the 2 secondary outcomes, the significance level was adjusted using the Bonferroni method to .025, while .05 was used for the primary outcome, and analysis was by assigned group (intention-to-treat).

Research Ethics

In this study, the researcher explained the objectives, procedures, and benefits of the research, and participants signed the consent

form voluntarily. Data were kept confidential and presented in aggregate without identifying individuals or persons involved in incidents. Participants had the right to withdraw at any time without any effect on their work. Incident data were used without identifying patients in accordance with the Personal Data Protection Act B.E. 2562 (2019), and after the study ended, the control group received the same training and access to the dashboard.

Results

1. General Information and Risk Management Information Needs

1.1 General Characteristics of the Sample

The sample comprised 60 participants: 49 females (81.67%) and 11 males (18.33%), with a mean age of 38.45±7.62 years. Most were registered nurses (41; 68.33%), followed by allied health personnel, namely pharmacists and medical technologists (11; 18.33%), and support staff (8; 13.33%). Mean work experience was 14.20±7.85 years and mean experience as a risk coordinator was 5.10±3.40 years. The two groups had similar general characteristics, as shown in Table 1.

1.2 Situation and Risk Management Information Needs

A review of 3,248 incidents over the previous 12 months found 1,914 incidents at level A-B (58.93%), 1,090 at level C-D (33.56%), and 244 at level E-I (7.51%). The focus group of 12 stakeholders identified five main needs: (1) viewing an overview of incidents by severity level and unit; (2) tracking monthly trends; (3) ranking frequent and high-risk incidents; (4) tracking the status of corrective actions and time to closure; and (5) receiving alerts for severe incidents. In addition, according to the question on risk information needs in the pre-intervention general information questionnaire, 78.33% of the sample (47 participants; 95% CI 65.80-87.93) needed risk information that was timely and self-accessible.

2. Dashboard Development and Quality Evaluation

2.1 Dashboard Development Process

The dashboard was developed in six steps following the design science research process. The result was a dashboard developed with Microsoft Power BI, connected to the incident reporting database and set to update automatically every day. It has five main screens: (1) incident overview; (2) monthly trends and unit comparison; (3) risk matrix and top 10 incidents; (4) tracking of corrective action status and time to closure; and (5) alerts for severity level E-I incidents. Users can access it by computer and smartphone through the hospital's internal network, with role-based access, as shown in Table 2. After evaluation by the experts and the 10 trial users, the color display by severity level was improved, the number of indicators on the first screen was reduced, and filters by unit and time period were added, as shown in Figure 1.

2 . 2 Dashboard Quality and Usability Evaluation Results

The 5 experts rated the overall appropriateness at the highest level (4.58±0.43) (Table 3), with data accuracy rated highest (4.72±0.36). The 30 users in the experimental group rated usability (SUS) at 82.50±8.12 points (95% CI 79.47-85.53; t = 8.43, df = 29, p < .001 versus the benchmark), which was higher than the 70.00-point benchmark considered acceptable.[17] The dashboard also reduced the time to compile the monthly report from an average of 4.50 working days to no more than 1 hour; this was a descriptive comparison with earlier data (measured from the start of data collection to submission of the report to the committee, for 2 reporting cycles after dashboard use, median 45 minutes (IQR 40-55 minutes)).

3. Effects of Dashboard Use on Knowledge, Competency, and Incident Reporting

3.1 Within-Group Pre-Post Comparison

The experimental group's knowledge score increased from 12.40±2.35 to 17.30±1.80 (difference 4.90, 95% CI 4.04-5.76; t = 11.67, df = 29, p < .001; Cohen's dz = 2.13), and its risk data analysis and utilization competency score increased from 19.83±3.42 to 26.47±2.55 (difference 6.64, 95% CI 5.48-7.80; t = 11.73, df = 29, p < .001; dz = 2.14). The control group's scores increased slightly but not to a statistically significant level, for both knowledge (12.57±2.41 to 13.10±2.28; difference 0.53, 95% CI -0.05 to 1.11; t = 1.87, df = 29, p = .072; dz = 0.34) and competency (20.10±3.55 to 20.87±3.38; difference 0.77, 95% CI -0.12 to 1.66; t = 1.76, df = 29, p = .089; dz = 0.32), as shown in Table 4.

3.2 Comparison Between the Experimental and Control Groups

Before the intervention, the knowledge scores (t = -0.28, df = 58, p = .783) and competency scores (t = -0.30, df = 58, p = .765) of the two groups were similar. After the intervention, the experimental group had a knowledge score 4.20 points higher than the control group (95% CI 3.14-5.26; t = 7.92, df = 58, p < .001; Cohen's d = 2.04) and a competency score 5.60 points higher (95% CI 4.05-7.15; t = 7.24, df = 58, p < .001; d = 1.87). The net differences (difference-in-differences) were 4.37 and 5.87 points, respectively. In the ANCOVA adjusting for pre-intervention scores, the adjusted difference was 4.29 for knowledge (95% CI 3.37-5.21) and 5.74 for competency (95% CI 4.40-7.08), as shown in Table 5.

3.3 Comparison of the Proportion Reporting Incidents Within 24 Hours

After the intervention, 26 of 30 participants in the experimental group (86.67%; 95% CI 69.28-96.24) reported at least 80.00% of their responsible incidents within 24 hours, higher than 18 of 30 in the control group (60.00%; 95% CI 40.60-77.34). The difference in proportions was 26.67% (95% CI 5.33-48.00; OR 4.33, 95% CI 1.20-15.61), a significant difference by the chi-square test (χ^2 = 5.45, df = 1, p = .020), as shown in Table 6.

Table 1 General characteristics of the sample by group (n = 30 per group)

General characteristics	Experimental	Control	Test statistic	p
Female	25 (83.33)	24 (80.00)	χ^2 = 0.11	.739
Age (years)	38.10±7.45	38.80±7.85	t = -0.35	.725
Profession: Registered nurse	21 (70.00)	20 (66.67)	χ^2 = 0.12	.944
Profession: Allied health	5 (16.67)	6 (20.00)	-	-
Profession: Support staff	4 (13.33)	4 (13.33)	-	-
Work experience (years)	13.85±7.90	14.55±7.85	t = -0.34	.736
Experience as a risk coordinator (years)	4.95±3.35	5.25±3.48	t = -0.34	.736
Clinical units	18 (60.00)	17 (56.67)	χ^2 = 0.07	.793
Non-clinical units	12 (40.00)	13 (43.33)	-	-



Figure 1 Design using red for high-level risk (G/H/I), yellow for moderate-level risk, and green for events

Table 2 Dashboard development process and activities for the experimental group

Week	Activities/content	Tools used	Duration	Academic rationale
1-2	Problem and needs analysis: focus group discussion with 12 stakeholders and review of incident data from the previous 12 months	Focus group question guide; incident reporting database	2 weeks (90-minute focus group)	Problem identification and objective definition according to the design science research process, and understanding users according to dashboard design principles[6,10]

Week	Activities/content	Tools used	Duration	Academic rationale
3-4	Design of indicators and data structure: defining risk indicators, a data dictionary, and screen drafts	Data dictionary; screen drafts (wireframe)	2 weeks	Indicators aligned with hospital and healthcare standards and designed so the overall picture can be monitored on a single screen[5,6]
5-7	Development of the prototype dashboard: connecting data, automated data cleaning, and building the 5 main screens	Microsoft Power BI; incident database	3 weeks	Use of easy-to-understand visual displays and reduction of the burden of manual data summarization[6,7]
8	Quality evaluation by 5 experts, trial with 10 users, and dashboard improvement	Expert quality assessment form; SUS questionnaire	1 week	Verification of accuracy and usability before real-world deployment[15,17]
9	Workshop on dashboard use and distribution of the manual (experimental group) with pre-intervention measurement	User manual; presentation slides; pre-intervention tests and assessments	3 hours	Strengthening perceived usefulness and ease of use, which are key factors in technology acceptance[9]
10-17	Use of the dashboard in routine work, weekly data review, monthly risk data review meetings, and a consultation channel	Dashboard; LINE consultation group	8 weeks (10-minute review each week; 60-minute meeting each month)	Continuous feedback helps practitioners use data to improve their work[7,8]

Table 3 Expert evaluation of dashboard appropriateness (n = 5)

Evaluation aspect	$\bar{x}$	S.D.	Appropriateness level
Data accuracy	4.72	0.36	Highest
Design and display	4.62	0.40	Highest
Ease of use	4.55	0.44	Highest
Usefulness for risk management	4.53	0.45	Highest
Data security and confidentiality	4.48	0.47	High
Overall	**4.58**	**0.43**	**Highest**

Table 4 Comparison of mean knowledge and risk data analysis and utilization competency scores before and after the intervention by group (n = 30 per group)

Variable	Group	Before ($\bar{x}$±S.D.)	After ($\bar{x}$±S.D.)	Difference (95% CI)	t	p
Knowledge (max 20)	Experimental	12.40±2.35	17.30±1.80	4.90 (4.04-5.76)	11.67	< .001*

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Variable	Group	Before ($\bar{x}$±S.D.)	After ($\bar{x}$±S.D.)	Difference (95% CI)	t	p
Knowledge (max 20)	Control	12.57±2.41	13.10±2.28	0.53 (-0.05 to 1.11)	1.87	.072
Competency (max 30)	Experimental	19.83±3.42	26.47±2.55	6.64 (5.48-7.80)	11.73	< .001*
Competency (max 30)	Control	20.10±3.55	20.87±3.38	0.77 (-0.12 to 1.66)	1.76	.089

Note: *Statistically significant at the .05 level

Table 5 Comparison of mean knowledge and risk data analysis and utilization competency scores between the experimental and control groups (n = 30 per group)

Variable	Time point	Experimental ($\bar{x}$±S.D.)	Control ($\bar{x}$±S.D.)	Difference (95% CI)	t	p
Knowledge (max 20)	Before	12.40±2.35	12.57±2.41	-0.17 (-1.40 to 1.06)	-0.28	.783
Knowledge (max 20)	After	17.30±1.80	13.10±2.28	4.20 (3.14-5.26)	7.92	< .001*
Knowledge (max 20)	After (ANCOVA)			4.29 (3.37-5.21)	-	< .001*
Competency (max 30)	Before	19.83±3.42	20.10±3.55	-0.27 (-2.07 to 1.53)	-0.30	.765
Competency (max 30)	After	26.47±2.55	20.87±3.38	5.60 (4.05-7.15)	7.24	< .001*
Competency (max 30)	After (ANCOVA)			5.74 (4.40-7.08)	-	< .001*

Note: *Statistically significant at the .05 level

Table 6 Comparison of the proportion reporting incidents within 24 hours between the experimental and control groups

Reporting outcome	Experimental (n = 30) No. (%; 95% CI)	Control (n = 30) No. (%; 95% CI)	Difference in proportion (95% CI)	χ^2	p
Reported within 24 hours per criterion	26 (86.67; 69.28-96.24)	18 (60.00; 40.60-77.34)	26.67 (5.33-48.00)	5.45	.020*
Did not report on time per criterion	4 (13.33)	12 (40.00)	-	-	-

Note: *Statistically significant at the .05 level

Discussion

In relation to objectives 1 and 2, the hospital's incident data were scattered across several sources and compiling reports took a long time, which is consistent with the observation that the value of an incident reporting system depends on analysis and timely feedback.[4] Users' need to see the overall picture on a single screen corresponds with dashboard design principles.[6] The developed dashboard was rated by experts at the highest level and had a SUS score above the acceptable benchmark,[17] which may be related to involving users from needs analysis through prototype trial and training. This is consistent with the concept that perceived usefulness and ease of use determine technology acceptance[9] (this study did not directly measure acceptance according to this concept) and with a design science research process that emphasizes repeated evaluation before real-world use.[10]

In relation to objective 3, after the intervention the experimental group had higher knowledge and risk data analysis and utilization competency scores than the control group (net differences of 4.37 and 5.87 points), while the control group increased slightly but not significantly. This may be explained by the dashboard allowing practitioners to immediately compare their own unit's data with the hospital overall, together with weekly data review and monthly meetings that provided continuous feedback, a mechanism that literature reviews propose enables dashboards to support improvement in quality of care.[7,8] However, this study did not measure the mechanism directly. According to Power BI access logs, the experimental group accessed the dashboard an average of 14.50 times per person over 8 weeks, and 90.00% attended both monthly review meetings; the effects of the dashboard, the training, and the review meetings cannot be separated. The higher proportion reporting incidents within 24 hours may reflect that seeing data and receiving feedback encouraged practitioners to report sooner, consistent with the proposal that feedback is a key factor enabling learning in incident reporting systems.[4] However, this indicator had no pre-intervention value and Fisher's exact test gave p = .039, so it should be interpreted as an exploratory result.

The limitations of this study were: 1) allocation was at the unit level rather than random assignment of individuals, and the cluster effect was not adjusted for;[14] 2) coordinators in both groups were in the same hospital, so contamination between groups was possible; 3) the findings reflect the combined effect of the dashboard, training, and follow-up, and the control group received no replacement activity, so the effect of the dashboard alone cannot be separated and an attention effect (Hawthorne effect) may be present; 4) the same tests and assessments were used before and after and their content matched the training, post-intervention scores were close to the ceiling (86.50% and 88.23% of the maximum score), and assessors were not blinded to group; 5) there was no pre-intervention value for the proportion reporting within 24 hours, and this indicator did not meet the adjusted criterion when Fisher's exact test was used; 6) statistical power was limited, as if the true effect size were 0.50, about 64 participants

per group would be needed;[13] and 7) the study was conducted in a single hospital, followed up for only 8 weeks, and did not measure patient-level outcomes such as the rate of severe incidents. The results should therefore be interpreted with caution, consistent with literature reviews indicating that evidence on dashboard outcomes remains limited.[7,8]

The findings are consistent with a study on developing a real-time risk management dashboard at Kalasin Hospital (built with Google Data Studio), which found that after implementation the mean reporting time for high-severity incidents (G/H/I) fell from 4.52 to 1.18 hours and timely reporting rose from 35.20% to 87.50%,[18] but that was a before-after comparison in the same hospital, so it has limited ability to separate the effect of the dashboard from other factors. A Cochrane review of audit and feedback found that effects on professional practice were small to moderate overall and varied widely across studies,[19] which is smaller than the effect sizes found in this study. Alternative explanations are therefore possible, namely that the test content matched the experimental group's training, competency was self-assessed and may be overestimated, assessors were not blinded to group, the Hawthorne effect, and unmeasured differences between units. The findings should therefore be confirmed with cluster-randomized studies in multiple hospitals.

Conclusion

The study achieved its objectives as follows. Objective 1: incident data were scattered across several sources, compiling the monthly report took an average of 4.50 working days, and users wanted a timely overview. Objective 2: a dashboard developed with Microsoft Power BI with 5 main screens was obtained; experts rated its appropriateness at the highest level (4.58±0.43) and its usability was 82.50±8.12 points. Objective 3: after 8 weeks of dashboard use, the experimental group had higher knowledge scores (difference 4.20, 95% CI 3.14-5.26) and competency scores (difference 5.60, 95% CI 4.05-7.15) than the control group and a higher proportion reporting within 24 hours, although the result for the last indicator did not meet the adjusted criterion when Fisher's exact test was used. It can therefore be concluded that the dashboard group had better outcomes, but causal conclusions cannot yet be drawn.

Recommendations

1. Recommendations for Applying the Findings

1.1 Pilot expansion of the dashboard to additional units, with evaluation.

1.2 Link it with the incident reporting system so that data update automatically, and bring the data to the risk management committee meeting every month.

1.3 Assign a system administrator with guidelines for keeping data confidential, and obtain a Power BI license appropriate to the number of users.

2. Recommendations for Future Research

Future studies should use a cluster-randomized design with control groups in multiple hospitals, calculating the number of units, ICC, and design effect; add a group that

receives training without the dashboard; follow up for at least 12 months; measure patient-level outcomes such as the rate and severity of incidents; and add predictive risk analysis.

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RESEARCH ARTICLE

Development of a Follow-up Model for Early Childhood Caregivers and Changes in Caregivers' Behaviors and Children's Oral Health Status at Huaimek Hospital, Kalasin Province

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Abstract

This action research, aimed to develop a follow-up model for early childhood caregivers and to evaluate changes in caregivers' oral health behaviors and children's oral health status. The study was conducted at the Dental Department, Huaimek Hospital, Kalasin Province, from October 2025 to September 2026 in three phases: a needs assessment among 30 caregivers, model development with five dental personnel, and a six-month implementation with 45 caregiver-child pairs (children aged 3-5 years at risk of dental caries). Data were analyzed using descriptive statistics, paired t-test, McNemar's test, and content analysis. The model had four components: shared goal setting, multichannel continuous follow-up, feedback and reinforcement, and a support network. After implementation, caregivers' knowledge scores increased by 4.45 points (95% CI 3.73-5.17; $p < .001$) and practice scores by 6.43 points (95% CI 5.26-7.60; $p < .001$). The proportion of caregivers brushing their child's teeth twice daily rose from 40.00% to 82.22%. Children's plaque index decreased by 0.77 (95% CI -0.93 to -0.61; $p < .001$) and gingivitis decreased from 62.22% to 28.89%. However, mean dmft increased by 0.13 (95% CI 0.01-0.25; $p = .035$) because of new caries in 11.11% of children. Caregiver satisfaction was at the highest level (4.56±0.41). Behavioral and plaque outcomes improved after six months, but without a comparison group or post-program follow-up, causal effects and sustainability cannot be concluded.

Keywords: follow-up model, early childhood caregivers, oral health behavior, early childhood caries

Introduction

Dental caries is the most common oral health problem among children worldwide. The World Health Organization (WHO) reports that approximately 60.00-90.00% of school-aged

children worldwide have experienced dental caries, particularly in developing countries, where caries rates are higher than in developed countries[1], and approximately 514 million children worldwide have untreated caries of the primary teeth[2]. Early childhood caries affects not only oral health but also children's growth, development, quality of life, and learning ability[3,4]. Children's oral health care depends largely on caregivers' behaviors, and caregivers' oral health behaviors have been reported to be directly associated with children's oral health status[5]. However, a key challenge is maintaining good behaviors over the long term, because one-time health education is insufficient to establish sustainable behaviors; continuous and systematic follow-up is therefore a key strategy for health behavior change[6].

In Thailand, the 9th National Oral Health Survey in 2023 found that 47.00% and 72.10% of children aged 3 and 5 years, respectively, had dental caries[7]. In Kalasin Province in fiscal year 2022, caries prevalence among 3-year-old children was 54.30% (51.20% in 2020 and 52.80% in 2021) and among 5-year-old children was 79.50% (76.40% in 2020 and 77.80% in 2021), with a mean of 6.80 decayed teeth per child, higher than the national average[8]. In Huaimek District in fiscal year 2022, caries prevalence was 56.70% among 3-year-old children and 81.20% among 5-year-old children, with a mean of 7.10 decayed teeth per child and an increasing trend since 2020[9]. In 2023 and 2024, 487 and 512 children aged 3-5 years received services, of whom 276 and 298 (56.67% and 58.20%), respectively, were at risk of dental caries[10]. Key contributing factors included most caregivers working in agriculture and having limited time for child care, a lack of accurate knowledge and understanding, inconvenient access to dental services, and previous health education being delivered only once without an effective follow-up system. In fiscal years 2023 and 2024, caries prevalence in Kalasin Province was 54.90% and 55.40% among 3-year-old children and 79.80% and 80.10% among 5-year-old children, while in Huaimek District it was 57.10% and 57.60% among 3-year-old children and 81.50% and 81.90% among 5-year-old children, respectively.

A widely used approach to achieving sustainable behavior change is a clearly structured and continuous follow-up model comprising goal setting, periodic monitoring, feedback, ongoing support, and adaptation to context[11]. This is combined with the Transtheoretical Model (TTM) of behavior change, which describes change through five stages: precontemplation, contemplation, preparation, action, and maintenance[12]; the concept of health literacy, defined as the ability to access, understand, appraise, and apply health information in decision-making[13]; and family systems theory, which views the family as the unit of care[14].

Educational text messaging to parents via mobile phones has also been used as a channel to support the control of early childhood caries[15]. However, studies that develop follow-up models integrating multiple channels and co-designed with dental teams to fit the context of community hospitals in Thailand remain limited. Moreover, a systematic review and meta-analysis

of motivational interviewing among parents to prevent early childhood caries yielded inconclusive results: a meta-analysis of four studies found no significant difference in new carious lesions, and three of six studies had a high risk of bias[29]. In Thailand, a randomized study at a public health service center in Bangkok, which used motivational interviewing combined with caries risk assessment and reinforcement every three months, found that the intervention group had a lower plaque index and fewer carious lesions than the control group at six-month follow-up[30].

Given the increasing trend of early childhood caries at both the provincial level and in Huaimek District, the importance of caregivers' behaviors for children's oral health, and the limitations of the previous service model, which lacked continuous follow-up, the researcher developed a sustainable follow-up model for early childhood caregivers suited to the context of Huaimek Hospital. The model is practical, makes cost-effective use of existing resources, and is expected to help reduce the incidence of early childhood caries, increase client satisfaction, and be scalable to other community hospitals with similar contexts.

Research hypothesis: after six months of implementing the follow-up model, caregivers will have higher knowledge, behavior, and oral health literacy scores, and children will have a lower plaque index and less gingivitis than before implementation.

Conceptual framework: the PDCA cycle was used as the framework for model development[16,17], with behavior change theory, health literacy, and family systems theory as the conceptual basis of the activities. The independent variable was the follow-up model (combined with initial training). The dependent variables were caregivers' knowledge, behaviors, and literacy, and children's oral health status. Sustainability was defined as maintenance of behaviors throughout the six-month follow-up period and was not assessed after the end of the program, as shown in Figure 1.

Figure **1 Research conceptual framework**

Independent variable		Dependent variables
Follow-up model for early childhood caregivers, combined with initial training 1) Shared assessment and goal setting 2) Multichannel continuous follow-up (clinic, telephone, LINE, caregiver group) 3) Feedback and reinforcement (behavior logbook, family involvement) 4) Support network (village health volunteers [VHVs], child development center [CDC] teachers) and integration into the service system Conceptual basis: PDCA cycle, TTM, health literacy, family systems theory	→	**Caregivers** - Knowledge - Oral health behaviors - Oral health literacy - Stage of behavior change - Satisfaction **Children** - Plaque index (primary outcome) - Gingivitis - dmft and new caries

Research Objectives

1) To study the problems and needs regarding follow-up of early childhood oral health care among caregivers at Huaimek Hospital, Kalasin Province
2) To develop a sustainable follow-up model for early childhood caregivers suited to the community context
3) To evaluate changes in oral health behaviors, oral health status, and satisfaction of early childhood caregivers before and after implementation of the follow-up model

Methods

This study was action research[16,17] based on the PDCA cycle, with outcome measurement in Phase 3. It was conducted at the Dental Department, Huaimek Hospital, Kalasin Province, from October 2025 to September 2026 (12 months) in the following phases: Phase 1, study of problems and needs (October-November 2025); Phase 2, development of the follow-up model (December 2025-February 2026); Phase 3, implementation and evaluation of the model with the sample over six months (March-August 2026); and summary and dissemination of results (September 2026). The results were reported according to the TREND guideline[18], the qualitative component according to SRQR[19], and the intervention was described according to TIDieR[20].

Population and Sample

Population: primary caregivers and early childhood children aged 3-5 years receiving services at the Dental Department, Huaimek Hospital, Huaimek District, Kalasin Province, where 487 children received services in 2023 and 512 in 2024, of whom 276 and 298, respectively, were at risk of dental caries.

Sample: the sample was divided by research phase. Phase 1 comprised 30 caregivers of children aged 3-5 years attending the dental clinic. Phase 2 comprised five stakeholders, two dentists and three dental assistants working in the Dental Department, who constituted all of its service providers; additional opinions were obtained from three caregiver representatives, two village health volunteers (VHVs), and two child development center (CDC) teachers during the review of the draft model. Phase 3 comprised 45 pairs of primary caregivers and early childhood children aged 3-5 years at risk of dental caries (one caregiver per child; no caregiver had more than one child in the sample), selected purposively according to the specified criteria by consecutive sampling of service attendees until the required number was reached. Of 62 pairs screened, 48 met the criteria and 3 declined to participate, leaving 45 pairs enrolled. The sample size was calculated using G*Power for a two-tailed paired t-test with an effect size (dz) of 0.50[21], a medium effect size according to Cohen's criteria, a significance level of .05, and a power of 0.90, yielding a minimum of 44 pairs without allowance for attrition; data were therefore collected from 45 pairs (power of 0.91 for one outcome; other outcomes were considered exploratory).

Inclusion Criteria

1) Children aged 3-5 years with at least one existing carious tooth; 2) risk behaviors, such as frequent consumption of sugary foods, irregular toothbrushing, or a family history of dental caries; and 3) the caregiver was the child's primary caregiver, had lived with the child for at least six months, could communicate in Thai, could use the LINE application, and consented to participate in the study.

Exclusion Criteria

1) Children with systemic diseases or special conditions affecting oral health care; 2) relocation or inability to be followed up throughout the study period; and 3) caregivers who requested to withdraw from the study. Attendance at the six follow-up activities was recorded for all participants, and data from all participants were analyzed according to their assigned group (intention-to-treat).

Research Instruments

The instruments consisted of 1) intervention instruments: the sustainable follow-up model for early childhood caregivers, a practice guideline manual, a caregiver behavior logbook, educational media, and a caregiver LINE group; and 2) data collection instruments: (1) a questionnaire on problems and needs; (2) a semi-structured interview guide; (3) assessments of caregivers' knowledge (15 items, 15 points), behaviors (10 items, 30 points), and oral health literacy (10 items, 40 points); (4) a five-item stage-of-change assessment classifying caregivers into five stages according to Prochaska and DiClemente, namely precontemplation, contemplation, preparation, action, and maintenance, with maintenance defined as performing the target behaviors continuously for at least six months (reliability 0.80); (5) a children's oral health record form covering the decayed, missing, and filled teeth (dmft) index, the plaque index (PI; score range 0-3), and gingival

status; and (6) a five-point rating scale satisfaction questionnaire. Content validity was examined by five experts, yielding an index of item-objective congruence (IOC) of 0.60-1.00. Reliability was tested in 30 caregivers with similar characteristics (different from the Phase 1 caregivers and the Phase 3 sample, as verified against name lists), yielding a KR-20 of 0.78 for the knowledge assessment and Cronbach's alpha coefficients of 0.84, 0.86, and 0.91 for the behavior, literacy, and satisfaction assessments, respectively. The two examining dentists were calibrated before data collection, yielding a kappa of 0.85.

Procedures

Phases 1 and 2 corresponded to the Plan step (October 2025-February 2026), which involved studying the situation through observation of service practices, review of medical records and caries statistics for the previous three years, surveys of dental personnel and parents, two workshops, in-depth interviews with stakeholders, drafting of the model and manual, and expert review of their appropriateness. Phase 3 corresponded to the Do step (March-August 2026), which involved a baseline assessment, a hands-on workshop, provision of behavior logbooks, and follow-up every month during the first three months and every six weeks thereafter through clinic appointments, telephone, the LINE application, and caregiver groups. In the Check step, outcomes were evaluated at the end of the program in August 2026, and in the Act step, in September 2026, the results were used to refine the model, prepare a revised manual, and plan for scale-up.

Data Collection

In Phase 1, quantitative data were collected from 30 caregivers using questionnaires. In Phase 2, qualitative data were collected from two dentists and three dental assistants through in-depth interviews and workshops. In Phase 3, caregivers' behaviors were assessed and children's oral health status was examined by dentists before the program (March 2026) and after the program (August 2026) using the same instruments; the examiners were not blinded to the timing of the examinations. The number of teeth filled or treated during the program was recorded from the medical records and treatment records of the Dental Department. Satisfaction was then assessed, and a focus group was conducted with eight caregivers purposively selected to include those with large and small behavior changes. The researcher and one research assistant coded the data independently and then compared them, and trustworthiness was confirmed through triangulation and member checking. Dental personnel were also interviewed about the feasibility of continued implementation of the model.

Data Analysis

Descriptive statistics, including frequency, percentage, mean, and standard deviation (S.D.),

were used. Knowledge, behavior, literacy, and oral health index scores before and after the intervention were compared using the paired t-test (normality of the differences was checked with the Shapiro-Wilk test, and the Wilcoxon signed-rank test was used when assumptions were not met), reporting mean differences, 95% CIs, and Cohen's dz. Proportions before and after were compared using the exact McNemar's test, reporting differences in proportions and the numbers of discordant pairs. The primary outcome was the children's plaque index, tested at a significance level of .05, with Bonferroni adjustment (.05/11 = .0045) for the 11 secondary outcomes. Analyses were performed using IBM SPSS Statistics version 28, and qualitative data were analyzed using content analysis.

Research Ethics

This study was conducted in accordance with the ethical principles of human research [specify the name of the human research ethics committee, approval number, and approval date]. The researcher explained the objectives, procedures, benefits, and potential risks to the caregivers, who signed informed consent forms on their own behalf and as representatives of the children. Data were kept confidential, participants were not identified, results were presented in aggregate, and participants had the right to withdraw at any time without affecting their services. All children received necessary dental treatment according to standards, and data in the LINE group were handled in accordance with the Personal Data Protection Act B.E. 2562 (2019), with access restricted to the research team and the LINE group data deleted after the end of the program.

Results

1. Problems and needs regarding follow-up (Phase 1)

1.1 General characteristics of caregivers

Of the 30 early childhood caregivers, most were mothers (60.00%), followed by grandparents (26.67%), fathers (6.67%), and other relatives (6.67%). Their mean age was 35.40±8.20 years; 53.33% worked in agriculture, 86.67% had less than a bachelor's degree, and 56.67% had a household income of less than 10,000 baht per month, as shown in Table 1.

Table **1** General characteristics of caregivers and children in Phase **1** (n = **30**) and Phase **3** (n = **45** pairs)

Characteristic	Phase 1 (n = 30) n (%)	Phase 3 (n = 45) n (%)
Relationship to child: Mother	18 (60.00)	28 (62.22)
Grandparent	8 (26.67)	11 (24.44)
Father	2 (6.67)	4 (8.89)

Characteristic	Phase 1 (n = 30) n (%)	Phase 3 (n = 45) n (%)
Other relative	2 (6.67)	2 (4.44)
Caregiver age (years), $\bar{x}$±S.D. (range)	35.40±8.20 (22-58*)	34.80±7.60 (21-56)
Agricultural occupation	16 (53.33)	25 (55.56)
Education below bachelor's degree	26 (86.67)	38 (84.44)
Household income below 10,000 baht/month	17 (56.67)	26 (57.78)
Child age (years), $\bar{x}$±S.D. (range)	-	4.10±0.80 (3-5)
Male child	-	24 (53.33)

1.2 Problems and needs regarding follow-up

Twenty-four caregivers (80.00%, 95% CI 61.43-92.29) had never been followed up after receiving health education, 70.00% had no channel for consulting dental personnel, only 11 (36.67%, 95% CI 19.93-56.14) brushed their child's teeth twice daily, and 63.33% regularly gave their child sugary drinks. Regarding needs, 86.67% of caregivers wanted follow-up and reminders via the LINE application, 76.67% wanted demonstrations and hands-on toothbrushing practice, 70.00% wanted appointments at convenient dates and times, and 60.00% wanted village health volunteers (VHVs) or child development center (CDC) teachers to assist with follow-up. These findings were consistent with data from observation of service practices and medical record review, which identified problems with the previous model: health education was provided only once without follow-up, there was no communication channel with parents, no behavior-monitoring tool, no feedback, and no appropriate appointment system.

2. Development of the sustainable follow-up model (Phase 2)

2.1 The developed follow-up model

From two workshops and in-depth interviews with five stakeholders, a follow-up model with four components was developed: 1) shared assessment and goal setting, assessing each caregiver's behaviors, literacy, and stage of change; 2) multichannel continuous follow-up, including clinic appointments, telephone, the LINE application, and caregiver groups, with follow-up every month during the first three months and every six weeks thereafter; 3) feedback and reinforcement through behavior logbooks and individualized advice, with the involvement of family members; and 4) a support network and integration into the service system, including VHVs, CDC teachers, and data recording in the hospital system. Component 1 arose from the lack of a behavior-monitoring tool and the need to set goals appropriate to each caregiver's readiness, based on the Transtheoretical Model of behavior change[12]. Component 2 arose from the 86.67% of caregivers who wanted follow-up via the LINE application and the 70.00% who

wanted appointments at convenient dates and times, based on the concepts of structured follow-up and mobile phone messaging[11,15]. Component 3 arose from the lack of feedback and used demonstration and hands-on practice based on the concept of health literacy[13]. Component 4 arose from the 60.00% of caregivers who wanted VHVs or CDC teachers to assist with follow-up and from stakeholders' suggestions in the workshops, based on family systems theory[14], as shown in Table 2.

Table 2 Follow-up activities according to the developed model (Month 0 = March 2026)

Month	Activities/Content	Tools	Duration	Academic rationale
0 (Mar 2026)	Baseline assessment, children's oral examination, stage-of-change assessment and shared goal setting, hands-on workshop, toothbrushing demonstration and practice	Assessment forms, oral health record form, manual, behavior logbook	120 minutes	Stage-of-change assessment to select appropriate strategies[12]; demonstration and hands-on practice help develop health literacy[13]
1 (Apr 2026)	Clinic appointment, logbook review, feedback, and individual problem-solving of barriers	Behavior logbook, stage-of-change assessment form	30 minutes	Feedback and ongoing support are components of effective follow-up[11]
2 (May 2026)	Telephone and LINE follow-up, reminder and encouragement messages, establishment of a caregiver group for sharing experiences	Telephone, LINE application, caregiver group	15 minutes	Reduces time and travel barriers; mobile phone messaging supports parents[15]
3 (Jun 2026)	Clinic appointment, reinforcement, reassessment of stage of change, and strategy adjustment	Stage-of-change assessment form, behavior logbook	30 minutes	Monitors progression through the stages and prevents relapse to previous behaviors[12]
4.50 (Jul 2026)	Telephone and LINE follow-up, coordination with VHVs or CDC teachers to help with reminders, and involvement of family members	Telephone, LINE application, follow-up record form	15 minutes	Views the family as the unit of care and strengthens community support networks[14]
6 (Aug 2026)	Post-program assessment, children's oral examination, satisfaction assessment, and focus group	Same assessment forms, oral health record form, satisfaction questionnaire	60 minutes	Comparison of pre- and post-program results using the same instruments, and gathering of suggestions to refine the model according to the PDCA cycle

2.2 Quality review and refinement of the model

Five experts, comprising two dental public health dentists, one pediatric dentist, one health educator, and one community nurse, each with at least 10 years of experience, reviewed the model and manual, yielding an IOC of 0.80-1.00. The researcher revised the model according to their suggestions, such as shortening LINE messages and adding illustrations, resulting in a practice guideline manual and a set of follow-up tools. Content analysis of the interviews identified five themes: a multichannel appointment and reminder system, individualized feedback, adaptation of activities to the stage of change, the role of community networks, and data recording linked to the service system.

3. Effects of the follow-up model on caregivers' behaviors and children's oral health status (Phase 3)

3.1 Caregivers' oral health behaviors

All 45 caregiver-child pairs completed both the pre- and post-assessments (100.00%) with no loss to follow-up, where "complete" meant having data for all outcomes both before and after the intervention. Twenty-eight caregivers were mothers (62.22%), with a mean age of 34.80±7.60 years; the children's mean age was 4.10±0.80 years, and 24 (53.33%) were boys. After implementation of the model, caregivers' knowledge scores increased from 8.42±2.31 to 12.87±1.64 (difference 4.45, 95% CI 3.73-5.17; t = 12.44, df = 44, p < .001, dz = 1.85), behavior scores increased from 18.64±3.82 to 25.07±2.95 (difference 6.43, 95% CI 5.26-7.60; t = 11.06, p < .001, dz = 1.65), and oral health literacy scores increased from 24.18±5.40 to 31.76±4.12 (difference 7.58, 95% CI 6.02-9.14; t = 9.78, p < .001, dz = 1.46). Post-intervention scores represented 85.80%, 83.57%, and 79.40% of the maximum scores, respectively. Forty-one caregivers (91.11%) had increased knowledge scores; of the remaining 4 (8.89%), 3 had unchanged scores and 1 had a decreased score, as shown in Table 3.

Table 3 Comparison of caregivers' mean knowledge, behavior, and oral health literacy scores before and after implementation of the follow-up model (n = 45; paired t-test)

Variable	Maximum score	Before ($\bar{x}$±S.D.)	After ($\bar{x}$±S.D.)	Difference (95% CI)	t (df = 44)	p
Oral health knowledge	15	8.42±2.31	12.87±1.64	4.45 (3.73-5.17)	12.44	< .001*
Oral health care behaviors	30	18.64±3.82	25.07±2.95	6.43 (5.26-7.60)	11.06	< .001*
Oral health literacy	40	24.18±5.40	31.76±4.12	7.58 (6.02-9.14)	9.78	< .001*

Note: *Statistically significant at the .05 level

3.2 Children's oral health status

The mean decayed, missing, and filled teeth (dmft) before and after implementation were 5.42±2.86 and 5.55±2.90 teeth per child, an increase of 0.13 teeth (95% CI 0.01-0.25; t = 2.18, df = 44, p = .035, dz = 0.32), due to six new

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carious teeth in five children (11.11%, 95% CI 3.71-24.05); this was an unfavorable result and did not meet the adjusted significance threshold. Meanwhile, untreated decayed teeth (dt) decreased from 4.07±2.21 to 1.89±1.61 teeth per child (difference -2.18, 95% CI -2.77 to -1.59; t = -7.50, p < .001, dz = -1.12), partly due to fillings or treatment during the program, and the plaque index decreased from 1.82±0.46 to 1.05±0.38 (difference -0.77, 95% CI -0.93 to -0.61; t = -9.93, p < .001, dz = -1.48), as shown in Table 4.

Table 4 Comparison of children's mean oral health status before and after implementation of the follow-up model (n = **45**; paired t-test)

Variable	Before ($\bar{x}$±S.D.)	After ($\bar{x}$±S.D.)	Difference (95% CI)	t (df = 44)	p
Mean decayed, missing, and filled teeth (dmft) (teeth/child)	5.42±2.86	5.55±2.90	0.13 (0.01-0.25)	2.18	.035*
Untreated decayed teeth (dt) (teeth/child)	4.07±2.21	1.89±1.61	-2.18 (-2.77 to -1.59)	-7.50	< .001*
Plaque index (maximum score 3)	1.82±0.46	1.05±0.38	-0.77 (-0.93 to -0.61)	-9.93	< .001*

Note: *Statistically significant at the .05 level

3.3 Caregivers' behaviors and children's gingivitis

The number of caregivers who brushed their child's teeth twice daily increased from 18 to 37 (40.00% to 82.22%), those who used an appropriate amount of fluoride toothpaste increased from 23 to 41 (51.11% to 91.11%), those who limited sugary drinks increased from 15 to 31 (33.33% to 68.89%), and those who brought their child for dental check-ups as scheduled increased from 21 to 40 (46.67% to 88.89%). Caregivers in the maintenance stage increased from 5 to 36 (11.11% to 80.00%), while children with gingivitis decreased from 28 to 13 (62.22% to 28.89%). All variables changed in a favorable direction. In theory, the maintenance stage requires continuous practice for at least six months. In this study, stages were classified from responses to the stage-of-change assessment based on Prochaska and DiClemente[12]: caregivers who performed all target behaviors continuously for at least six months were classified as being in the maintenance stage, and those who had performed them for less than six months were classified as being in the action stage, as shown in Table 5.

Table **5 Comparison of percentages of caregivers' behaviors and children's gingivitis before and after implementation of the follow-up model (n = 45)**

Variable/Status	Before n (%)	After n (%)	Difference (percentage points)	exact McNemar's p
Brushing the child's teeth twice daily	18 (40.00)	37 (82.22)	42.22	< .001*
Using an age-appropriate amount of fluoride toothpaste	23 (51.11)	41 (91.11)	40.00	< .001*
Limiting sugary drinks to no more than once daily	15 (33.33)	31 (68.89)	35.56	.001*
Bringing the child for dental check-ups as scheduled	21 (46.67)	40 (88.89)	42.22	< .001*
Caregiver in the maintenance stage	5 (11.11)	36 (80.00)	68.89	< .001*
Child with gingivitis	28 (62.22)	13 (28.89)	-33.33	.001*

Note: *Statistically significant at the .05 level

4. Caregivers' satisfaction with the follow-up model

Caregivers' overall satisfaction with the follow-up model was at the highest level (4.56±0.41 out of 5; 95% CI 4.44-4.68; interpreted according to Best's criteria: 1.00-1.80 = lowest, 1.81-2.60 = low, 2.61-3.40 = moderate, 3.41-4.20 = high, and 4.21-5.00 = highest). By aspect, appropriateness of content (4.62±0.45), benefits received (4.60±0.43), follow-up channels (4.58±0.47), convenience of practice (4.51±0.52), and readiness for continued implementation (4.49±0.55) were all at the highest level. Forty-one caregivers (91.11%) attended at least five of the six follow-up activities, where "attended" meant that the caregiver came to the scheduled appointment or responded to telephone or LINE follow-up through at least one channel in that round. Twenty-nine caregivers (64.44%) attended all six sessions, 12 (26.67%) attended five, and 4 (8.89%) attended four. In the focus group, caregivers commented that the LINE reminders and the logbook helped them not to forget and kept them motivated, and they suggested adding toothbrushing demonstration videos, while dental personnel considered the model practical and able to be integrated into routine work.

Discussion

The Phase 1 results showed that the main problems of the previous care model were one-time health education without follow-up, a lack of communication channels, and the absence of an appropriate appointment system. This is consistent with reports that key barriers for parents in caring for their children's oral health include workload and limited time, travel costs, lack of motivation when no oral problems are visible, and lack of toothbrushing skills[22]. The developed model therefore reduced time and travel barriers through multichannel follow-up and provided individualized feedback, in line with the concept that follow-up requires goals,

periodic monitoring, and ongoing support[11]. In addition, caregivers who receive family support can maintain good care behaviors for longer[23], and families with good communication have better oral health behaviors[24]. The model thus engaged family members, VHVs, and CDC teachers, consistent with family systems theory[14]. However, the study did not directly measure the roles of family members, VHVs, or CDC teachers; follow-up records showed only that VHVs and CDC teachers assisted with a total of 68 follow-up contacts for 22 caregivers (48.89%), accounting for 25.19% of all 270 follow-up contacts (45 caregivers × 6 sessions).

The significant increases in caregivers' knowledge, behavior, and oral health literacy scores, and the increase in the proportion of caregivers in the maintenance stage from 11.11% to 80.00%, may be related to the fact that the developed model did not provide health education only once, but assessed each caregiver's stage of change individually, selected strategies appropriate to each stage, and provided continuous follow-up and reinforcement to prevent relapse to previous behaviors[12]. This is consistent with studies indicating that one-time health education is insufficient to establish sustainable behaviors[6]. Demonstration and hands-on practice helped develop caregivers' oral health literacy, which is associated with better child care behaviors[25,26], and follow-up via mobile phone messaging supported parents' caries-prevention behaviors[15]. However, post-intervention scores were close to the ceiling and were measured with the same instruments, so the results may also reflect a practice effect or socially desirable responding.

Regarding children's oral health status, the plaque index and gingivitis, which are sensitive to changes in toothbrushing behavior, improved after implementation of the model. In contrast, dmft is a cumulative index that does not decrease even when caries are treated; therefore, only a slight increase was observed, due to six new carious teeth in five children (11.11%), while untreated caries decreased. In the short term, the incidence of new caries and the number of untreated decayed teeth should therefore be used as outcome indicators alongside dmft. This finding is consistent with data showing that parental care behaviors are associated with children's dmft: children whose parents brushed their teeth regularly had a mean dmft of 3.20 teeth, compared with 6.80 teeth among children who received irregular care[27]. Caregivers' satisfaction was at the highest level, but data on cost and workload are not yet available to establish the feasibility of continued implementation; based on a preliminary estimate, the team spent an average of approximately 15 minutes per caregiver per follow-up contact.

Compared with studies showing different or null results, a randomized trial in Thailand that used a social media messaging service for 190 pairs of caregivers of children aged 6-36 months found better feeding and toothbrushing behaviors than with dental health education provided during service visits, but no reduction in the consumption of sugary snacks and drinks and no prevention of caries progression[31]. Meanwhile, a

randomized trial in Brazil that sent educational messages to parents via WhatsApp every two weeks found improved parental eHealth literacy and control of caries severity[15]. A meta-analysis of motivational interviewing among parents found no significant difference in new carious lesions[29]. These findings are consistent with the present study, in which caregivers' behaviors and plaque improved but new caries still occurred, suggesting that behavior change over six months may not yet be sufficient to reduce caries incidence, particularly among high-risk children with existing caries. In contrast, a randomized study in Bangkok with reinforcement every three months found reductions in plaque and carious lesions compared with a control group[30]. These differences may be due to the intensity and duration of follow-up and the characteristics of the samples. In addition, the findings of this study may have alternative explanations, including 1) regression to the mean, because high-risk children with existing caries were selected[28]; 2) the effects of dental treatment and professional tooth cleaning in the clinic during the program, which can directly reduce plaque and gingival inflammation; 3) the Hawthorne effect and social desirability bias, because behavioral data were self-reported by caregivers; 4) a practice effect from using the same instruments; and 5) bias from examiners who were not blinded to the timing of the examinations. Confirmation through studies with comparison groups and blinded examiners is therefore necessary.

The limitations of this study are as follows: 1) it was a single-group pre-post study without a comparison group, so the effects of the model could not be separated from the effects of time, regression to the mean[28], and the Hawthorne effect; 2) the sample was selected purposively from children with existing caries, and caregivers were required to be able to use LINE, so the findings cannot be applied to people without access to technology; 3) the model was a multicomponent intervention (training, follow-up, logbooks, LINE group, and clinical treatment), so the effect of follow-up could not be separated from the other components, and the reduction in untreated caries was partly due to treatment; 4) the examiners were dentists on the team and were not blinded to timing, behavioral data were self-reported by caregivers, and the same instruments were used before and after; 5) statistical power was sufficient for only one outcome (dz 0.50); if the true effect were smaller, as for dmft (dz 0.32), approximately 119 pairs would be required, and multiple tests were performed; and 6) follow-up lasted only six months with no measurement after the end of the program, so sustainability could not be concluded; in addition, the study was conducted in a single hospital, and no cost data were available.

Conclusion

This study achieved its objectives as follows: 1) most caregivers had never been followed up after receiving health education (80.00%) and wanted follow-up via LINE (86.67%); 2) a four-component follow-up model

with a manual was developed; 3) after six months of implementation, caregivers' knowledge, behavior, and literacy scores increased, and the proportion of caregivers brushing their child's teeth twice daily increased to 82.22%; 4) the plaque index and gingivitis improved, but dmft increased slightly due to new caries; and 5) caregivers' satisfaction was at the highest level (4.56±0.41). It can therefore be concluded that favorable changes in behaviors and plaque were observed after implementation of the model, but causal effects and sustainability cannot yet be concluded.

Recommendations

1. **Recommendations for applying the research findings**

1.1 The model should continue to be piloted at the Dental Department, Huaimek Hospital, integrated into the existing service and data recording systems, and re-evaluated.

1.2 The capacity of dental personnel should be developed and resources allocated for communication channels, including one unit-owned mobile phone with a LINE Official Account for the Dental Department, a main responsible person (dental assistant) for approximately 3-4 hours per week, manuals and logbooks, and toothbrushing demonstration kits, at a total direct cost of approximately 350 baht per caregiver, or approximately 21,000-24,500 baht per year for 60-70 caregivers.

1.3 Scale-up to child development centers, subdistrict health promoting hospitals, and community hospitals with similar contexts should be considered once results from studies with comparison groups are available.

2. **Recommendations for future research**

2.1 Studies with comparison groups should be conducted, such as two-arm cluster randomized trials (by child development center or village) comparing training alone with training plus follow-up, or stepped-wedge designs, with sample sizes calculated based on the ICC and design effect.

2.2 Long-term follow-up of at least 12-24 months should be conducted, with measurement after the end of the program to assess sustainability, using new caries incidence as a pre-specified primary outcome.

2.3 Economic cost-effectiveness should be studied, and different intensities of follow-up channels should be compared.

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RESEARCH ARTICLE

Development of a Hypertension Care Model through Family and Caregiver Capacity Enhancement at Chaiyo Hospital, Ang Thong Province

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Abstract

This research and development study aimed to develop a hypertension care model through family and caregiver capacity enhancement and to evaluate its effects on family and caregiver capacity, blood pressure (BP), and BP control. The study was conducted at Chaiyo Hospital, Ang Thong Province, from October 2025 to September 2026. Participants were 60 dyads of patients with uncontrolled hypertension and their primary caregivers (30 dyads per group), selected purposively and allocated by catchment area (non-randomized). The experimental group received a 12-week program. Data were analyzed using descriptive statistics, paired t-test, independent t-test, and chi-square test. The experimental group's capacity score increased from 61.63±7.88 to 85.47±7.38, systolic BP decreased from 151.60±9.45 to 138.37±10.14 mmHg, and diastolic BP decreased from 90.33±5.74 to 81.83±5.99 mmHg (all $p < .001$). After the intervention, the experimental group scored 18.90 points higher in capacity (95% CI 15.42-22.38; $p < .001$), had lower systolic BP by 8.60 mmHg (95% CI 3.65-13.55; $p = .001$) and lower diastolic BP by 5.50 mmHg (95% CI 2.39-8.61; $p = .001$), and had a higher proportion of controlled BP (60.00% vs 26.67%; $p = .009$). Participants receiving the model showed better changes than the controls over 12 weeks; however, allocation was non-randomized and baseline diastolic BP differed slightly, so the findings should be confirmed in randomized, longer-term studies.

Keywords: hypertension, family capacity enhancement, caregivers, care model, blood pressure control

Introduction

Hypertension is a major global public health problem. The World Health Organization reported that in 2024, approximately 1.4 billion adults aged 30-79 years had hypertension, but only about 320 million (23%) had their blood pressure controlled.[1] Hypertension is a major risk factor for cardiovascular

disease, stroke, chronic kidney disease, and dementia, and the number of patients worldwide continues to rise with population ageing.[1,2] In Thailand, the Sixth Thai National Health Examination Survey (2019-2020) found a hypertension prevalence of 25.4% among people aged 15 years and older, or approximately 14 million people,[3] yet as of 6 May 2025, only 7.4 million patients were registered for treatment.[4]

Ang Thong Province has a higher proportion of older adults than the national average: in 2023, 17.03% of its population was aged 65 years or older, the seventh highest in the country.[5] Chaiyo Hospital is a community hospital serving residents of Chaiyo District and nearby areas. In fiscal year 2025, 1,850 patients with hypertension were registered for care, of whom only 58.40% achieved blood pressure control according to the target criteria, based on data from the Health Data Center of the Ministry of Public Health,[6] below the Ministry of Public Health target of 60%. Most patients are older adults who depend on family members to manage their medications, prepare meals, measure their blood pressure at home, and accompany them to medical appointments; however, many caregivers lack adequate knowledge and skills, making continuing care at home ineffective.

Thai and international clinical practice guidelines emphasize pharmacological treatment combined with lifestyle modification and continuous blood pressure monitoring,[7,8] which require patients to manage almost all of their own care in daily life. The concept of empowerment,[9] Orem's self-care theory,[10] and Bandura's self-efficacy theory[11] explain that individuals and families who receive appropriate knowledge, skills, and support gain greater capability and confidence in managing their health. A systematic review found that self-monitoring of blood pressure improves medication adherence and health behaviors.[12] However, few studies in the context of community hospitals in Ang Thong Province have developed a care model in which families and caregivers participate from problem analysis through evaluation. Previous Thai studies, such as a study of collaboration between relatives and patients with uncontrolled hypertension at Phu Sing Hospital, Si Sa Ket Province,[13] the development of care guidelines for older adults with hypertension through family and community participation in Kalasin Province,[14] and a systematic review of community care programs involving families and village health volunteers,[15] support the role of families in patient care, but most focused on patient behaviors rather than on systematically enhancing caregiver capacity.

The conceptual framework of this study is that empowerment, self-care, and self-efficacy guide the design of activities for families and caregivers to enhance family and caregiver capacity, which is expected to improve patients' blood pressure and blood pressure control. The research hypothesis was that, after the intervention, the experimental group would have higher family and caregiver capacity and lower blood pressure than the control group.

Therefore, the research team developed a hypertension care model through family and caregiver capacity enhancement at Chaiyo Hospital and examined its effects on family and caregiver capacity, blood pressure levels, and blood pressure control among patients, to provide a guideline for

the hospital and the district health network in the future care of patients with hypertension.

Research Objectives

1) To study the situation and problems of care provided by families and caregivers for patients with hypertension at Chaiyo Hospital, Ang Thong Province
2) To develop a hypertension care model through family and caregiver capacity enhancement
3) To compare family and caregiver capacity, blood pressure, and blood pressure control of patients before and after implementation of the model, and between the experimental and control groups after the 12-week intervention

Methods

This was a research and development study combined with a two-group pretest-posttest quasi-experimental design, reported according to the TREND guideline.[16] Phases 1 and 2 used a mixed qualitative and quantitative approach, with qualitative data reported according to the SRQR guideline.[17] The study was conducted at Chaiyo Hospital, Ang Thong Province, from October 2025 to September 2026 in three phases: Phase 1, situation analysis (October-December 2025); Phase 2, model development and quality validation (January-March 2026); and Phase 3, implementation and evaluation (April-September 2026). The 12-week program was delivered from May to July 2026.

Population and Sample

Population consisted of dyads of patients with hypertension registered at the chronic disease clinic of Chaiyo Hospital and their primary caregivers in fiscal year 2026, with approximately 1,850 patients.

Sample consisted of patient-primary caregiver dyads who met the eligibility criteria. The sample size was calculated using G*Power[18] for an independent-means t-test with an effect size of d = 0.80,[19] a large effect according to Cohen's criteria[19] and consistent with the effects of family-involvement programs in previous Thai research,[13] a significance level of .05, and a power of 0.80, yielding 26 dyads per group. An additional 15% was added to compensate for attrition, giving 30 dyads per group, or 60 dyads in total. Participants were selected by purposive sampling from a list of eligible individuals and allocated by catchment area to prevent contamination between groups: the experimental group comprised Chaiyo, Chai Rit, and Thewarat Subdistricts, and the control group comprised Ratchasathit, Chawai, and Tri Narong Subdistricts. Allocation was non-randomized, unblinded, and unmatched. Each group comprised three subdistricts, selected for similar numbers of patients with uncontrolled hypertension, population characteristics, and access to services, and located in the catchment areas of different

service units to reduce information exchange between groups.

Inclusion criteria: Patients: aged 40 years or older; diagnosed with essential hypertension for at least 1 year; receiving continuous treatment at Chaiyo Hospital; mean blood pressure from the two most recent measurements of at least 140/90 mmHg; able to communicate in Thai; and willing to participate. Caregivers: family members aged 18 years or older, living in the same household as the patient, having cared for the patient for at least 6 months, not employed as paid caregivers, and willing to participate.

Exclusion criteria: Patients with severe complications, such as bedridden stroke, end-stage chronic kidney disease, or severe heart failure; patients with cognitive impairment or who relocated during the study; and participants who requested to withdraw from the study. Participants who missed activities remained in the analysis according to their assigned group, and the number of sessions attended was recorded.

Research Instruments

The instruments consisted of 1) the hypertension care model through family and caregiver capacity enhancement, comprising a 12-week program, a hypertension care manual for families, a home blood pressure record book, and a LINE group for follow-up and consultation; and 2) data collection instruments, including a general information questionnaire, a 25-item assessment of family and caregiver capacity in caring for patients with hypertension (total score 100), and a calibrated digital blood pressure monitor.

Content validity was examined by five experts, yielding IOC values of 0.80-1.00. The assessment was piloted with 30 patient-caregiver dyads who were not part of the sample, yielding a Cronbach's alpha reliability of 0.89, and 0.91 in the actual sample. The blood pressure monitor was calibrated by the medical equipment unit of Chaiyo Hospital before data collection, and the same device was used throughout the study.

Data Collection

The researcher and research assistants (two registered nurses trained in blood pressure measurement) collected data before the intervention and at the end of the program in week 12 in both groups. Blood pressure was measured in the seated position after at least 5 minutes of rest, twice at a 1-minute interval, and the mean was used. Blood pressure assessors were not blinded to patients' group allocation, which is noted as a study limitation. The experimental group received the developed model in addition to usual care, whereas the control group received standard care at the chronic disease clinic and received the manual at the end of the study. Reporting of the model's activities followed the TIDieR guideline,[20] as shown in Table 2.

Data Analysis

Data were analyzed using SPSS version 28. Descriptive statistics included frequency, percentage, mean, and standard deviation. Normality was tested using the Shapiro-Wilk test. Within-group pre-post comparisons used the paired t-test, between-group comparisons used the

independent t-test, and proportions were compared using the chi-square test. Analyses followed the intention-to-treat principle, and mean differences, 95% confidence intervals (95% CI), and effect sizes (Cohen's dz for paired data and Cohen's d for two independent groups) were reported.[19]

Because groups were not randomized and their baseline characteristics might differ, changes were compared between groups (difference-in-differences)[21] and analysis of covariance (ANCOVA) was performed with pre-intervention values as covariates.[21] For the four outcomes (capacity, systolic blood pressure, diastolic blood pressure, and the proportion with controlled blood pressure), the significance level for between-group comparisons was Bonferroni-adjusted to .05/4 = .0125; other comparisons were considered exploratory. Statistical significance was set at .05.

Research Ethics

This study adhered to the ethical principles of human research. The researcher explained the study objectives and procedures to all participating dyads, obtained signed informed consent before data collection, kept all data confidential and presented results only in aggregate, and informed participants of their right to withdraw from the study at any time without any effect on the treatment they received.

Results

1. Situation and Problems of Care for Patients with Hypertension by Families and Caregivers

1.1 General Characteristics of the Sample

All 60 dyads (30 dyads each in the experimental and control groups) completed the study. Most patients in both groups were female (63.33% and 66.67%, respectively; p = .787), with a mean age of 62.90±9.71 and 65.60±7.87 years (p = .241), a mean duration of illness of 9.40±4.21 and 8.23±5.95 years (p = .385), and comorbid diabetes in 26.67% and 23.33% (p = .766). Most caregivers were children (53.33%) or spouses (30.00%), with a mean age of 46.50±9.33 and 49.00±12.78 years (p = .390). No statistically significant differences in general characteristics were found between the two groups; however, the absence of a difference does not prove that the groups were balanced, as shown in Table 1.

Table 1 General characteristics of patients and caregivers by group (n = 30 per group)

Characteristic	Experimental group	Control group	p-value
Patients: female, n (%)	19 (63.33)	20 (66.67)	.787
Patients: age (years), $\bar{x}$±S.D.	62.90±9.71	65.60±7.87	.241
Patients: duration of illness (years), $\bar{x}$±S.D.	9.40±4.21	8.23±5.95	.385
Patients: comorbid diabetes, n (%)	8 (26.67)	7 (23.33)	.766
Caregivers: female, n (%)	21 (70.00)	20 (66.67)	.781

Characteristic	Experimental group	Control group	p-value
Caregivers: age (years), $\bar{x}$±S.D.	46.50±9.33	49.00±12.78	.390
Caregivers: relationship - child	16 (53.33)	16 (53.33)	1.000
Caregivers: relationship - spouse	9 (30.00)	9 (30.00)	
Caregivers: relationship - other	5 (16.67)	5 (16.67)	

1.2 Situation and Problems of Care

The Phase 1 situation analysis, which comprised a review of the medical records of 1,850 registered patients and focus group discussions with 12 patient-caregiver dyads and 8 health personnel, found that in fiscal year 2025, 58.40% of patients had controlled blood pressure, and identified four main problems (based on inductive content analysis by the researcher and two research assistants, with trustworthiness established through investigator triangulation): 1) caregivers lacked knowledge and skills in home blood pressure measurement and in recognizing abnormal symptoms; 2) patients forgot or stopped taking their medications on their own, with no one supervising their medication intake; 3) food prepared by families remained high in sodium; and 4) there was no channel for follow-up and consultation with health personnel between appointments.

2. Development of the Hypertension Care Model through Family and Caregiver Capacity Enhancement

2.1 The Developed Model

Based on the situation analysis together with the concepts of empowerment, self-care theory, and self-efficacy, a model with four components was developed: 1) joint assessment and goal setting with families; 2) enhancement of caregivers' knowledge and skills; 3) continuous support and follow-up at home; and 4) evaluation and reflection. The model was delivered as a 12-week program, with group activities and home visits in weeks 1, 2, 3, 4, 6, 8, and 12, and follow-up by telephone or LINE group once a week for 10-15 minutes in weeks 5, 7, and 9-11, as shown in Table 2.

Table 2 The 12-week program for enhancing family and caregiver capacity in caring for patients with hypertension

Week	Activities/content	Tools used	Duration	Academic rationale
1	Problem assessment, joint blood pressure goal setting with families, relationship building, and clarification of the caregiver's role	Assessment form, family care plan	60 minutes	Participation from the outset is central to empowerment[9]

Week	Activities/content	Tools used	Duration	Academic rationale
2	Education on hypertension, complications, and warning signs requiring a hospital visit	Manual, short videos	60 minutes	Knowledge is the foundation of the ability to care for oneself and others[10]
3	Skills training in home blood pressure measurement and recording in the record book	Digital blood pressure monitor, record book	60 minutes	Direct experience enhances self-efficacy[11,12]
4	Medication use and supervision of medication intake; practice in preparing weekly medications	Pill organizer, medication schedule	45 minutes	Medication adherence is central to blood pressure control[7,8]
6	Low-sodium diet, reading nutrition labels, and appropriate exercise	Sample food sets, nutrition labels	90 minutes	Lifestyle modification according to clinical practice guidelines[7,8]
8	Home visits and joint problem solving with families; reflection on experiences	Home visit form, LINE group	45 minutes	Continuous support in real-life settings enhances confidence[11]
12	Evaluation, lesson summary, recognition of achievements, and planning for continuing care	Assessment form, record book	60 minutes	Reviewing outcomes and sustaining behaviors[9]

2.2 Quality Validation and Pilot Testing of the Model

The model was reviewed by five experts: one internist, one pharmacist, two registered nurses at the professional level, and one nutritionist, yielding IOC values of 0.80-1.00. It was piloted with six patient-caregiver dyads who were not part of the sample, and the week 6 content was reduced to suit older adults' available time before actual implementation.

3. Effects of the Hypertension Care Model through Family and Caregiver Capacity Enhancement

3.1 Within-Group Comparisons Before and After the Intervention

In the experimental group, the family and caregiver capacity score after the intervention was significantly higher than before (an increase of 23.84 points, 95% CI 21.13-26.55; $t(29) = 17.97$, $p < .001$, $dz = 3.28$), systolic blood pressure decreased by 13.23 mmHg (95% CI 10.29-16.17; $t(29) = -9.20$, $p < .001$, $dz = -1.68$), and diastolic blood pressure

decreased by 8.50 mmHg (95% CI 6.48-10.52; t(29) = -8.62, p < .001, dz = -1.57). In the control group, the capacity score increased by 3.50 points (95% CI 0.85-6.15; t(29) = 2.70, p = .011, dz = 0.49), systolic blood pressure decreased by 3.80 mmHg (95% CI -7.67 to 0.07; p = .054), and diastolic blood pressure decreased by 0.70 mmHg (95% CI -3.09 to 1.69; p = .553). Because these confidence intervals include both no change and clinically meaningful reductions, it cannot be concluded that blood pressure in the control group did not change, as shown in Table 3 (t values for changes were calculated from post - pre differences).

Table 3 Comparison of mean family and caregiver capacity scores and patients' blood pressure before and after receiving the model, by group (n = 30 per group; paired t-test)

Variable	Group	Pre ($\bar{x}$±S.D.)	Post ($\bar{x}$±S.D.)	Difference (95% CI)	t	p-value
Family and caregiver capacity (total score 100)	Experimental	61.63±7.88	85.47±7.38	23.84 (21.13-26.55)	17.97	< .001*
	Control	63.07±7.79	66.57±6.00	3.50 (0.85-6.15)	2.70	.011*
Systolic blood pressure (mmHg)	Experimental	151.60±9.45	138.37±10.14	-13.23 (-16.17 to -10.29)	-9.20	< .001*
	Control	150.77±9.25	146.97±8.97	-3.80 (-7.67 to 0.07)	-2.01	.054
Diastolic blood pressure (mmHg)	Experimental	90.33±5.74	81.83±5.99	-8.50 (-10.52 to -6.48)	-8.62	< .001*
	Control	88.03±6.82	87.33±6.05	-0.70 (-3.09 to 1.69)	-0.60	.553

*Statistically significant at the .05 level

3.2 Comparisons Between the Experimental and Control Groups

Before the intervention, there were no statistically significant differences between the two groups in capacity or blood pressure (p = .163-.731), although baseline diastolic blood pressure in the experimental group was 2.30 mmHg higher (d = 0.36). After the intervention, the experimental group had a capacity score 18.90 points higher than the control group (95% CI 15.42-22.38; p < .001, d = 2.81), systolic blood pressure 8.60 mmHg lower (95% CI 3.65-13.55; p = .001, d = 0.90), and diastolic blood pressure 5.50 mmHg lower (95% CI 2.39-8.61; p = .001, d = 0.91). When pre-to-post changes were compared between groups, the experimental group had a greater increase in capacity by 20.34 points (95% CI 16.63-24.05; p < .001), a greater reduction in systolic blood pressure by 9.43 mmHg (95% CI 4.68-14.18; p < .001), and a greater reduction in diastolic blood pressure by

7.80 mmHg (95% CI 4.74-10.86; p < .001). All comparisons met the .0125 threshold, and after adjustment for pre-intervention values using ANCOVA, the results remained in the same direction, with capacity 19.54 points higher and systolic and diastolic blood pressure 9.05 and 6.69 mmHg lower, respectively (p < .001), as shown in Table 4.

Table 4 Comparison of mean family and caregiver capacity scores and patients' blood pressure between the experimental and control groups (n = 30 per group; independent t-test)

Variable	Experimental group ($\bar{x}$±S.D.)	Control group ($\bar{x}$±S.D.)	Between-group difference (95% CI)	t	p-value
Capacity, pre (total score 100)	61.63±7.88	63.07±7.79	-1.43 (-5.49 to 2.62)	-0.71	.482
Capacity, post	85.47±7.38	66.57±6.00	18.90 (15.42-22.38)	10.88	< .001*
Systolic blood pressure, pre (mmHg)	151.60±9.45	150.77±9.25	0.83 (-4.00 to 5.66)	0.35	.731
Systolic blood pressure, post (mmHg)	138.37±10.14	146.97±8.97	-8.60 (-13.55 to -3.65)	-3.48	.001*
Diastolic blood pressure, pre (mmHg)	90.33±5.74	88.03±6.82	2.30 (-0.96 to 5.56)	1.41	.163
Diastolic blood pressure, post (mmHg)	81.83±5.99	87.33±6.05	-5.50 (-8.61 to -2.39)	-3.54	.001*
Change in capacity (post - pre)	23.84±7.27	3.50±7.10	20.34 (16.63-24.05)	10.97	< .001*
Change in systolic blood pressure (mmHg)	-13.23±7.88	-3.80±10.35	-9.43 (-14.18 to -4.68)	-3.97	< .001*
Change in diastolic blood pressure (mmHg)	-8.50±5.40	-0.70±6.39	-7.80 (-10.86 to -4.74)	-5.11	< .001*

*Statistically significant at the .05 level

3.3 Blood Pressure Control

After the intervention, 18 patients (60.00%) in the experimental group achieved blood pressure control (<140/90 mmHg), significantly more than the 8 patients (26.67%) in the control group (difference 33.33 percentage points, 95% CI 8.26-53.17; $\chi^2(1) = 6.79$, p = .009; OR = 4.13, 95% CI 1.39-12.27). Fisher's exact test yielded a consistent result (p = .018), as shown in Table 5.

Table 5 Comparison of the proportion of patients achieving blood pressure control after the intervention between the experimental and control groups (n = 30 per group; chi-square test)

Blood pressure control status	Experimental group, n (%)	Control group, n (%)	Difference, percentage points (95% CI)	χ^2	p-value
Controlled (<140/90 mmHg)	18 (60.00)	8 (26.67)	33.33 (8.26-53.17)	6.79	.009*
Uncontrolled	12 (40.00)	22 (73.33)			

Note: *Statistically significant at the .05 level

Discussion

The situation analysis found that 58.40% of patients had controlled blood pressure, consistent with the national and global picture in which blood pressure control has not yet reached its targets.[1,4] The key problems identified were caregivers' lack of skills in blood pressure measurement, supervision of medication intake, and dietary sodium control, which are daily household activities that older patients cannot manage on their own. This is consistent with self-care theory, which holds that when a patient's capability is insufficient to meet care demands, caregivers are needed to provide support.[10] This finding is also consistent with Thai studies showing that the involvement of relatives and families is a key factor in modifying self-care behaviors among patients with uncontrolled hypertension.[13-15]

The developed model involved families from problem assessment and joint goal setting onward, in line with the principle of empowerment, which gives service recipients a role in decision-making.[9] Hands-on skills training, such as home blood pressure measurement and medication preparation, enhanced caregivers' self-efficacy,[11] and continuous follow-up by telephone, LINE group, and home visits gave families a source of advice between appointments. The model was validated by experts with IOC values of 0.80-1.00, indicating content appropriateness, but this is not yet evidence of its effectiveness or feasibility in routine practice in community hospitals.

After the intervention, the experimental group had higher capacity and lower blood pressure than the control group (differences of 18.90 points in capacity and of 8.60 and 5.50 mmHg in systolic and diastolic blood pressure, respectively) and a higher proportion of patients with controlled blood pressure. This is consistent with research showing that self-monitoring of blood pressure combined with support improves medication adherence and health behaviors.[12] The between-group difference in systolic blood pressure (8.60 mmHg) is relatively large for a behavioral intervention and may reflect both the effect of the model and bias from non-randomized allocation. By comparison, an individual patient data meta-analysis found that self-monitoring of blood pressure reduced systolic blood pressure by a mean of 3.2 mmHg (95% CI 1.6-4.9) at 12 months, and that self-monitoring alone without co-interventions was not associated with lower

blood pressure.[22] The difference observed in this study was therefore larger than that found in large randomized trials. The increase in capacity scores in the control group (3.50 points) may have resulted from usual care, awareness of being in a study, or regression to the mean.[23,25]

Study limitations include: 1) participants were not randomized and were allocated by catchment area, so the results may be confounded by between-area differences; 2) the baseline characteristics of the two groups were not entirely equivalent (diastolic blood pressure in the experimental group was 2.30 mmHg higher), and the ANCOVA adjustment for pre-intervention values was estimated from summary statistics rather than raw data; 3) clustering by catchment area was not taken into account;[24] 4) blood pressure assessors may have known patients' group allocation; 5) capacity was assessed by self-report, which may be subject to social desirability bias; 6) the study was conducted in a single hospital with a modest sample size, limiting generalizability; and 7) follow-up lasted only 12 weeks, so long-term effects remain unknown.

Conclusion

The hypertension care model through family and caregiver capacity enhancement at Chaiyo Hospital consists of four components: joint assessment and goal setting, enhancement of caregivers' knowledge and skills, continuous support and follow-up, and evaluation and reflection, delivered as a 12-week program. After implementation of the model, the experimental group had higher capacity, lower blood pressure, and a higher proportion of controlled blood pressure than the control group. However, because allocation was non-randomized and the baseline characteristics of the two groups were not entirely equivalent, the results should be interpreted as an association consistent with the model's effectiveness rather than as a causal conclusion.

Recommendations

1. Recommendations for Applying the Research Findings

1.1 The model should continue to be implemented in the chronic disease clinic of Chaiyo Hospital on a pilot basis, with repeated evaluation.

1.2 Nurses and village health volunteers (VHVs) should be trained to conduct activities according to the manual, and the quality of activity implementation should be monitored.

1.3 Before scaling up to subdistrict health promoting hospitals (SHPHs) in the Chaiyo District network, the model should be tested in service units with different contexts, and its costs and workload should be evaluated.

2. Recommendations for Future Research

2.1 A cluster randomized controlled trial should be conducted in multiple areas, with the sample size calculated to account for the design effect.

2.2 Long-term outcomes should be followed up for 6-12 months and analyzed with adjustment for pre-intervention values.

2.3 Outcomes related to complications, quality of life, caregiver burden, and cost-effectiveness should be evaluated.

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