

ORIGINAL ARTICLE

Effects of a structured nutrition literacy enhancement program on the knowledge, skills, and dietary behaviors of village health volunteers in Rural Thailand: Single-group repeated-measures evaluation

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ABSTRACT

Non-communicable diseases represent Thailand's predominant health challenge, with nutrition-related factors critically influencing disease prevention. Village health volunteers (VHVs) serve as essential healthcare intermediaries connecting Thailand's primary care system to rural communities but demonstrate insufficient nutrition literacy competencies. This single-group repeated-measures study evaluated a structured 12-week nutrition literacy enhancement program among 35 VHVs in rural Thailand from July to October 2024. The intervention comprised interactive workshops, peer learning sessions, and community-based activities grounded in Social Cognitive Theory and Adult Learning Theory. Validated instruments assessed three nutrition literacy domains (functional, interactive/communicative, and critical), nutrition knowledge, and dietary behaviors at baseline and weeks 4, 8, 12, and 16. Linear mixed-effects models with random intercepts and AR(1) covariance structures were used to analyze trajectories. Significant improvements occurred across all domains: Knowledge increased 60.3% ($\beta=0.52$, 95%CI: 0.48-0.56, $p<.001$), functional literacy improved 26.4% ($\beta=0.24$, 95%CI: 0.21-0.27, $p<.001$), interactive/communicative literacy increased 24.8% ($\beta=0.22$, 95%CI: 0.19-0.25, $p<.001$), critical literacy enhanced 23.5% ($\beta=0.21$, 95%CI: 0.18-0.24, $p<.001$), and dietary behaviors improved 25.1% ($\beta=0.23$, 95%CI: 0.20-0.26, $p<.001$). Cross-sectional correlations at follow-up ranged from $r=0.60$ to $r=0.73$. This theory-based nutrition literacy program effectively improved VHV competencies, supporting its integration into Thailand's VHV training curriculum to strengthen community-based NCD prevention.

Keywords:

nutrition literacy, village health volunteers, health promotion, community intervention

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INTRODUCTION

Non-communicable diseases (NCDs) constitute Thailand's primary health burden, accounting for 74% of national mortality.¹ Thailand's NCDs epidemic includes diabetes which affects 3.5 million individuals, hypertension which impacts 13.5 million adults, and dyslipidemia which affects 19.2 million people, reflecting critical dietary risk factors including excessive sodium (mean intake 3,636 mg/day), sugar-sweetened beverages, low fruit and vegetable consumption, and unhealthy fats that drive cardiovascular disease, stroke, and metabolic disorders.^{2,3}

Thailand's primary healthcare system strategically relies on village health volunteers (VHVs) to bridge formal healthcare services and rural communities, serving as the frontline mechanism for NCD prevention and control.⁴ Over one million VHVs currently serve Thailand's rural populations, with each volunteer typically responsible for 10-15 households, conducting health screenings, providing health education, and promoting behavioral modifications that directly address NCD risk factors.⁵ However, national assessments indicate that VHVs often possess limited nutrition knowledge and literacy skills, potentially compromising their effectiveness as community nutrition change agents.⁶

Nutrition literacy encompasses functional literacy (understanding nutrition information), interactive/communicative literacy (extracting and applying information through social interactions), and critical literacy (critically analyzing information to exert control over nutrition situations) and represents the essential mechanism through which VHVs can effectively translate nutrition science into community action.⁷ Enhancing nutrition literacy among VHVs enables them to accurately interpret dietary guidelines, communicate evidence-based nutrition advice, critically evaluate commercial food

claims, and model healthy dietary behaviors, thereby influencing household-level dietary practices that modify NCD risk.⁸

Despite the strategic role of VHVs, existing nutrition training programs in Thailand have predominantly employed traditional didactic approaches with limited emphasis on comprehensive nutrition literacy development across functional, interactive, and critical domains.⁹ Recent systematic reviews demonstrate that theory-based, participatory nutrition literacy interventions employing interactive pedagogical approaches, practical skill-building, and peer learning yield superior outcomes compared to conventional lecture-based methods.¹⁰ However, multi-time-point evaluations examining nutrition literacy trajectories among VHVs remain scarce in the Thai context, limiting evidence for optimal intervention design and timing.¹¹

This study aimed to evaluate the effectiveness of a comprehensive, theory-based nutrition literacy enhancement program on functional, interactive/communicative, and critical nutrition literacy domains, in addition to nutrition knowledge and dietary behaviors among village health volunteers in rural Thailand using a single-group repeated-measures design with five assessment points.

METHODS

Study Design and Setting

This single-group repeated-measures evaluation employed five assessment points (baseline, weeks 4, 8, 12, and 16) to examine trajectories of nutrition literacy, knowledge, and dietary behaviors following a 12-week intervention. The study was conducted in Thung Thong Sub-district, Nong Bua District, Nakhon Sawan Province, Thailand from July 19, 2024 to October 20, 2024. This rural agricultural community with an active VHV network

represented the typical central Thai rural population.

Sample Size and Participants

The sample size for the repeated-measures design with five assessment points was calculated using established methods for linear mixed-effects models.¹² The parameters included effect size $f=0.40$ (medium-to-large based on previous nutrition literacy interventions), $\alpha=.05$, power=0.80, five repeated measures, and an expected correlation of 0.50 between measurements. The calculation yielded $n=35$ participants as adequate for detecting meaningful intervention effects with 80% power.

The inclusion criteria were as follows: Registered VHVs with ≥ 1 year of service, aged 20-60 years, willingness to complete the 12-week program, and smartphone access for support communications. The exclusion criteria were as follows: A formal nutrition or dietetics education, concurrent enrollment in other health training programs, or planned extended absence during the study period. All 35 enrolled participants completed all five assessment waves (100% retention).

Research Instruments

Thai Nutrition Literacy Assessment Tool: This 36-item instrument measured three core nutrition literacy domains using a 5-point Likert scale (1=strongly disagree to 5=strongly agree):

1. Functional literacy (12 items): Understanding nutrition labels, interpreting dietary guidelines, comprehending nutrient information, and basic nutrition knowledge application.

2. Interactive/communicative literacy (12 items): Extracting nutrition information through social interactions, discussing nutrition with community members,

sharing dietary advice, and collaborative problem-solving.

3. Critical literacy (12 items): Critically evaluating commercial food claims, analyzing conflicting nutrition information, recognizing marketing tactics, and advocating for healthy food environments.

The content validity index was 0.92 after being assessed by six public health specialists. Exploratory factor analysis ($n=120$ VHVs from adjacent districts) confirmed a three-factor structure: Kaiser-Meyer-Olkin=0.89, and Bartlett's test $\chi^2=1,247.3$ ($p<.001$), explaining 68.4% of variance. Factor loadings ranged from 0.58-0.84. Internal consistency: Overall Cronbach's $\alpha=0.93$ at baseline, 0.94 at week 4, 0.95 at weeks 8 and 12, and 0.94 at week 16. Domain-specific reliability ranged from $\alpha=0.81$ -0.88 across all waves.

Dietary Behavior Questionnaire: Twenty items evaluated meal patterns, food group consumption, portion control, and dietary guideline adherence using a 5-point frequency scale (1=never to 5=always). Content validity index was 0.91. Internal consistency: Cronbach's $\alpha=0.89$ at baseline, 0.90 at week 4, 0.91 at weeks 8 and 12, and 0.90 at week 16. Criterion validity against 3-day food records: $r=0.74$.

Intervention Program

The 12-week program integrated Social Cognitive Theory¹³ (modeling, self-efficacy, and outcome expectations) and Adult Learning Theory¹⁴ (experiential learning, problem-centered approach, and self-direction) through four phases:

Phase 1 - Knowledge Building (Weeks 1-8): Eight weekly 3-hour workshops were delivered by trained nutrition specialists, which covered Thai dietary guidelines and NCD prevention (addressing sodium, sugar, and unhealthy fats), macronutrients/micronutrients and disease relationships, food safety practices,

nutrition assessment techniques, behavior change communication, and community nutrition planning. Workshops employed interactive methods (case discussions, role-plays, and demonstrations) tailored for varied educational backgrounds through visual aids, local food examples, and group activities.

Phase 2 - Skill Development (Weeks 3-12): Four bi-weekly 2-hour peer learning sessions (weeks 3, 6, 9, 12) facilitated experience sharing, collaborative problem-solving for nutrition challenges, and collective efficacy building through appreciative inquiry techniques. Sessions explicitly linked functional knowledge to interactive communication skills and critical evaluation capacities.

Phase 3 - Practical Application (Weeks 1-12): Weekly community practice activities included conducting household nutrition assessments, organizing cooking demonstrations using local ingredients, developing culturally appropriate nutrition education materials addressing NCD dietary risks, and implementing community nutrition activities. Structured feedback from facilitators reinforced progressive skill development across functional, interactive, and critical domains.

Phase 4 - Support Resources: Support resources were provided, including illustrated nutrition guides that were adapted for low-literacy populations, portion size models, 30 healthy local recipes with nutritional analysis, quick reference cards, and WhatsApp groups for ongoing support. Delivery fidelity was monitored through attendance logs (mean attendance: 94.3%, range: 88.6-100%) and session checklists.

Data Collection and Ethical Considerations

Trained research assistants conducted standardized face-to-face assessments at five time points: Baseline (week 0), weeks 4, 8, 12 (post-intervention), and week 16

(follow-up). Each assessment took 45-60 minutes and was conducted at participants' preferred private locations. Quality assurance included research assistant training with inter-rater reliability $\kappa > 0.88$, standardized protocols, immediate data review, 15% random verification, and double data entry.

Statistical Analysis

Data analysis employed R software version 4.3.0 with the nlme package. Descriptive statistics summarized participant characteristics and outcome variables. Normality was confirmed using Shapiro-Wilk tests (all $p > .05$).

Primary analyses used linear mixed-effects models to examine outcome trajectories over five time points. Models included time (weeks 0, 4, 8, 12, 16) as a fixed effect, random intercepts to account for individual variability, and first-order autoregressive AR(1) covariance structure to accommodate within-person temporal correlation. Piecewise time coding distinguished the intervention phase (weeks 0-12) from the maintenance phase (weeks 12-16). The model specification was as follows:

$$Y_{ij} = \beta_0 + \beta_1(\text{time_intervention}_{ij}) + \beta_2(\text{time_maintenance}_{ij}) + b_{0i} + \varepsilon_{ij}$$

where Y_{ij} represents the outcome for individual i at time j , β_0 is the baseline level, β_1 is the slope during the intervention phase, β_2 is the slope during maintenance phase, b_{0i} is the random intercept for individual i , and ε_{ij} is the residual error with AR(1) structure. Model diagnostics included residual plots and Akaike Information Criterion comparisons. Effect sizes were calculated as standardized mean differences: Cohen's d with interpretations of 0.2 (small), 0.5 (medium), and 0.8 (large).¹⁵ Cross-sectional Pearson correlations at week 16 examined associations between outcomes. Statistical significance was set at $p < .05$ for two-tailed tests.

RESULTS

Participant Characteristics

All 35 participants were female with a mean age of 47.2 ± 10.8 years (Table 1).

Table 1. Baseline Characteristics of Participants (n=35)

Characteristic	n (%) or Mean $\pm$ SD
Age (years)	47.2 $\pm$ 10.8
Education level	
Primary education	19 (54.3%)
Secondary education	11 (31.4%)
Post-secondary education	5 (14.3%)
VHV service duration (years)	8.2 $\pm$ 5.1
Personal NCD diagnosis (hypertension/diabetes)	8 (22.9%)
BMI (kg/m ²)	24.9 $\pm$ 3.8

Note: VHV=Village Health Volunteer; NCD=Non-communicable disease; BMI=Body Mass Index

Nutrition Literacy Domain Trajectories

Linear mixed-effects models revealed significant improvements across all three nutrition literacy domains (Table 2). Functional literacy increased from baseline 3.69 ± 0.84 to post-intervention 4.66 ± 0.29 (26.4% improvement), with a significant intervention-phase slope $\beta = 0.24$ (95%CI: 0.21-0.27, $p < .001$) and a sustained maintenance-phase slope $\beta = 0.08$ (95%CI: 0.04-0.12, $p < .001$), yielding a large effect size $d = 1.52$. Interactive/communicative

literacy improved from 3.54 ± 0.83 to 4.42 ± 0.32 (24.8% improvement), with an intervention slope $\beta = 0.22$ (95%CI: 0.19-0.25, $p < .001$) and a maintenance slope $\beta = 0.07$ (95%CI: 0.03-0.11, $p < .001$), with an effect size $d = 1.38$. Critical literacy enhanced from 3.65 ± 0.81 to 4.51 ± 0.30 (23.5% improvement), with an intervention slope $\beta = 0.21$ (95%CI: 0.18-0.24, $p < .001$) and a maintenance slope $\beta = 0.09$ (95%CI: 0.05-0.13, $p < .001$), yielding an effect size $d = 1.41$.

Table 2. Changes in Nutrition Literacy Domains Using Linear Mixed-Effects Models

Domain	Baseline Mean $\pm$ SD	Week 12 Mean $\pm$ SD	Intervention Slope β (95%CI)	p-value	Effect Size d
Functional literacy	3.69 $\pm$ 0.84	4.66 $\pm$ 0.29	0.24 (0.21-0.27)	<.001	1.52
Interactive/communicative literacy	3.54 $\pm$ 0.83	4.42 $\pm$ 0.32	0.22 (0.19-0.25)	<.001	1.38
Critical literacy	3.65 $\pm$ 0.81	4.51 $\pm$ 0.30	0.21 (0.18-0.24)	<.001	1.41

Note: Linear mixed-effects models with random intercepts and AR(1) covariance structure. Intervention slope represents the change per week during weeks 0-12. CI=Confidence interval. All models showed excellent fit with normally distributed residuals.

Nutrition Knowledge and Dietary Behavior Trajectories

Nutrition knowledge demonstrated substantial improvement from baseline 8.91 ± 1.75 to post-intervention 14.28 ± 1.26 (60.3% increase), with an intervention

slope $\beta = 0.52$ (95%CI: 0.48-0.56, $p < .001$) and maintenance slope $\beta = 0.11$ (95%CI: 0.05-0.17, $p < .001$), yielding a large effect size $d = 3.39$. Dietary behaviors improved from 3.83 ± 0.66 to 4.79 ± 0.26 (25.1% increase), with an intervention slope $\beta = 0.23$

(95%CI: 0.20-0.26, $p<.001$) and a maintenance slope $\beta=0.06$ (95%CI: 0.02-0.10, $p=.003$), yielding an effect size $d=1.94$ (Table 3).

Table 3. Changes in Nutrition Knowledge and Dietary Behaviors Using Linear Mixed-Effects Models

Outcome	Baseline Mean $\pm$ SD	Week 12 Mean $\pm$ SD	Intervention Slope β (95%CI)	p-value	Effect Size d
Nutrition knowledge	8.91 $\pm$ 1.75	14.28 $\pm$ 1.26	0.52 (0.48-0.56)	<.001	3.39
Dietary behaviors	3.83 $\pm$ 0.66	4.79 $\pm$ 0.26	0.23 (0.20-0.26)	<.001	1.94

Note: Linear mixed-effects models with random intercepts and AR(1) covariance structure. Intervention slope represents the change per week during weeks 0-12. CI=Confidence interval.

Trajectory Visualization

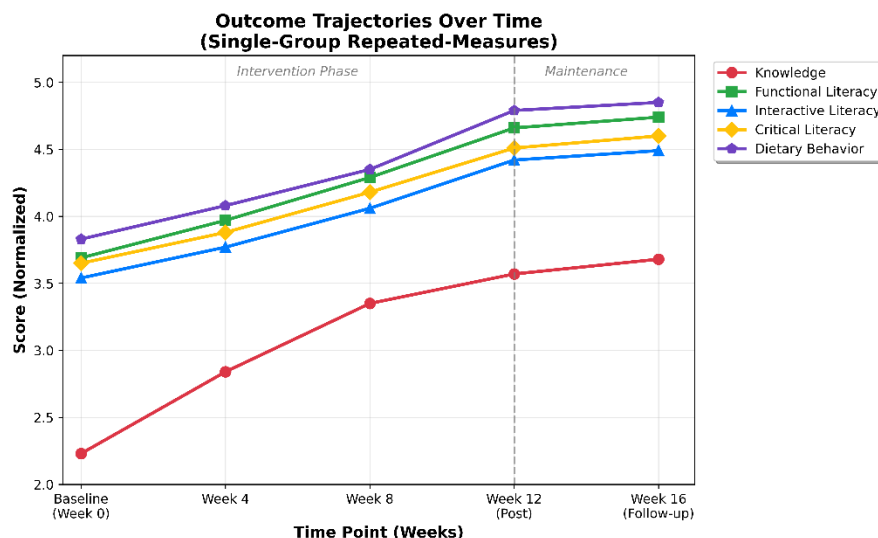


Figure 1. Trajectories of nutrition knowledge, nutrition literacy domains, and dietary behaviors across five assessment points showing consistent improvements during the intervention phase (weeks 0-12) and sustained gains during the maintenance phase (weeks 12-16).

Cross-Sectional Associations at Follow-Up

Pearson correlations at week 16 revealed significant positive associations: functional literacy with knowledge ($r=0.69$, $p<.001$), interactive literacy with knowledge ($r=0.65$, $p<.001$), critical literacy with knowledge ($r=0.62$, $p<.001$), dietary behaviors with functional literacy ($r=0.73$, $p<.001$), dietary behaviors with interactive literacy ($r=0.68$, $p<.001$), and dietary behaviors with critical literacy ($r=0.60$, $p<.001$). These moderate-to-strong correlations indicate interconnected improvements across cognitive, literacy, and behavioral domains. However, as these represent cross-sectional associations at a single time point without controlling for potential confounders (age, education,

VHV tenure, and attendance), no causal or mediational inferences can be drawn regarding temporal relationships between constructs.

DISCUSSION

This single-group repeated-measures evaluation demonstrated that a structured 12-week nutrition literacy enhancement program significantly improved functional, interactive/communicative, and critical nutrition literacy domains, nutrition knowledge, and dietary behaviors among village health volunteers in rural Thailand. Linear mixed-effects models revealed substantial and progressive improvements during the

intervention phase with sustained gains at one-month follow-up, supporting the program's effectiveness for building comprehensive nutrition literacy competencies essential for VHVs' role in Thailand's NCD prevention strategy.

The domain-specific improvements illuminate how the intervention systematically developed nutrition literacy across its theoretical components. Functional literacy gains (26.4%) reflect enhanced capacity to understand nutrition labels, interpret dietary guidelines, and comprehend nutrient-disease relationships foundational competencies for evidence-based nutrition counseling. Interactive/communicative literacy improvements (24.8%) demonstrate strengthened abilities to extract nutrition information through social interactions and engage in effective nutrition discussions with community members, critical for VHVs' health educator role. Critical literacy enhancements (23.5%) indicate improved capacity to critically evaluate commercial food claims and analyze conflicting nutrition information, enabling VHVs to protect communities from misleading marketing and advocate for healthy food environments.

The progressive trajectory across domains suggests a developmental cascade whereby functional knowledge provides the foundation for interactive communication skills, which in turn enable critical evaluation capacities. This aligns with Nutbeam's health literacy framework proposing that functional literacy is a prerequisite for interactive literacy, which subsequently enables critical literacy.¹⁶ The program's phased structure, emphasizing knowledge building (Phase 1), skill development through peer learning (Phase 2), and practical application (Phase 3), appears to have successfully facilitated this developmental progression.

The substantial knowledge improvement (60.3%) and behavioral changes (25.1%) demonstrate successful translation of literacy competencies into both cognitive understanding and personal dietary practices. This finding holds particular significance given VHVs' role as community role models, where personal dietary practices influence the credibility and effectiveness of health promotion activities.¹⁷ The continued improvement between post-intervention and follow-up assessments suggests progression toward habit formation, consistent with behavior change theories indicating that weeks 8-12 of the program facilitated a transition from conscious behavior modification to automaticity.¹⁸

Several intervention design features likely contributed to the effectiveness of the program. The integration of Social Cognitive Theory principles, including observational learning through cooking demonstrations, self-efficacy building through graduated practice activities, and outcome expectations linked to NCD prevention, provided robust theoretical mechanisms for behavior change.¹³ Adult Learning Theory principles emphasizing experiential learning, problem-centered approaches addressing real community nutrition challenges, and learner self-direction through peer sessions facilitated deep learning among the VHVs who had varied educational backgrounds.¹⁴ The cultural adaptation using local food examples, familiar measurement units, and community-specific scenarios enhanced relevance and engagement.¹⁹ Workshop delivery methods intentionally accommodated educational diversity through visual aids, hands-on activities, and group discussions rather than solely lecture-based approaches.

These improvements directly address Thailand's NCD prevention priorities by equipping VHVs to effectively

communicate evidence-based dietary guidance targeting modifiable risk factors including excessive sodium, sugar-sweetened beverages, low fruit-vegetable intake, and unhealthy fats that drive the nation's cardiovascular disease, stroke, and diabetes epidemics.² Enhanced VHV nutrition literacy represents a strategic mechanism for translating national dietary guidelines into household-level behavioral changes, leveraging Thailand's extensive primary care infrastructure to achieve population-level NCD risk reductions.⁴

Implications and Future Directions

These findings support the systematic integration of theory-based nutrition literacy programs into Thailand's VHV training curriculum. Given that over one million VHVs serve Thailand's rural populations, scaling up this intervention could substantially impact population nutrition outcomes and NCD prevention.⁵ The program framework demonstrates adaptability for other health literacy domains including physical activity promotion, mental health support, and chronic disease self-management.

Implementation research should examine optimal strategies for scaling up the intervention across diverse rural contexts, including train-the-trainer models and digital learning modules to enhance sustainability and reach.²⁰ Future studies employing controlled designs with comparison groups would strengthen causal inference. Additionally, longer follow-up periods (6-12 months) would enable the assessment of sustained behavior change and community-level impacts. Moreover, investigation of mediating mechanisms linking specific literacy domains to behavior change would refine theoretical models and optimize intervention components. Further, economic evaluations assessing cost-effectiveness would inform resource allocation decisions for national implementation.

Strengths and Limitations

The strengths of this study include the repeated-measures design with five assessment points enabling trajectory analysis, the 100% retention rate, the use of validated instruments with strong psychometric properties across all assessment waves, the comprehensive evaluation spanning three nutrition literacy domains plus knowledge and behavior, and the rigorous statistical approach using linear mixed-effects models with appropriate covariance structures.

Nonetheless, the limitations of this study warrant consideration. The single-group design without a comparison group limits causal inference compared to randomized controlled trials, though multiple pre-intervention and post-intervention measurements strengthen internal validity. The one-month follow-up period demonstrates short-term sustainability but omits assessment of long-term maintenance. The exclusively female sample reflects typical VHV demographics but limits generalizability to male community health workers. Moreover, reliance on self-reported measures may introduce social desirability bias, although validated instruments and confidential data collection mitigated this concern. All correlational analyses represent cross-sectional associations at single time points without controlling for potential confounders (age, education, VHV tenure, and attendance), precluding any causal or mediational inferences regarding relationships between constructs. In addition, common-method bias may inflate associations due to all measures being self-reported at the same assessment wave.

RECOMMENDATIONS

Based on these findings, the researchers recommend:

(1) Integrating this theory-based nutrition literacy program into Thailand's national VHV training curriculum, emphasizing functional, interactive, and critical literacy development.

(2) Developing train-the-trainer models and digital learning modules to facilitate scalable implementation across diverse rural settings while maintaining intervention fidelity.

(3) Conducting implementation research examining optimal delivery strategies, dose-response relationships, and adaptation requirements for varied contexts.

(4) Evaluating long-term program sustainability through 6-12 month follow-up assessments and cost-effectiveness analyses to inform resource allocation.

(5) Extending the intervention framework to other health literacy domains (physical activity, mental health, and chronic disease management) to comprehensively strengthen VHV competencies.

(6) Investigating mechanisms through which nutrition literacy domains influence behavior change to refine theoretical models and optimize intervention components for maximum community impact on Thailand's NCD prevention priorities.

CONCLUSION

This single-group repeated-measures evaluation provides robust evidence supporting a structured 12-week nutrition literacy enhancement program's effectiveness for village health volunteers in rural Thailand. Linear mixed-effects models demonstrated significant improvements across functional literacy

(26.4%), interactive/communicative literacy (24.8%), critical literacy (23.5%), nutrition knowledge (60.3%), and dietary behaviors (25.1%), with sustained gains at one-month follow-up. These findings support systematic integration of theory-based nutrition literacy programs into VHV training curricula as a strategic approach to strengthening community-based nutrition promotion capabilities and addressing Thailand's nutrition-related NCD burden through enhanced primary care workforce competencies.

AUTHOR CONTRIBUTIONS

SS: Conceptualization, Investigation, Data curation and Writing original draft. AU: Methodology, Formal analysis and Writing review & editing. YB: Investigation, Data curation, and Validation. WS: Investigation, Resources and Project administration. NC: Data curation, Formal analysis and Visualization. KR: Conceptualization, Investigation, Methodology, Data curation, Supervision and Writing review & editing.

ETHICAL CONSIDERATION

This research was approved by the Human Research Ethics Committee of Valaya Alongkorn Rajabhat University under the Royal Patronage, Protocol Number 0020/2567, approval date July 19, 2024, COA Number 0059/2567. All participants provided written informed consent. Data confidentiality was maintained through coded identifiers and secure storage.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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