ORIGINAL ARTICLE

Predictors of post-pandemic COVID-19 preventive behaviors among Hmong Communities in Rural Phayao, Thailand: A PRECEDE–PROCEED study

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ABSTRACT

This study examined predictors of COVID-19 preventive behaviors among Hmong communities in rural Phayao, Thailand, using the PRECEDE–PROCEED framework. A cross-sectional survey was conducted between November 2022 and March 2023 among adults residing in three Hmong villages. Stratified simple random sampling was applied to household lists, yielding a final sample of 402 respondents. Data were collected using a structured questionnaire comprising sociodemographic variables, five theory-based determinants, and a multi-item preventive behavior scale. The instrument demonstrated strong content validity (item–objective congruence index, IOC = 0.97) and acceptable internal consistency (KR-20 = 0.82 for knowledge; Cronbach's α = 0.77–0.80 for attitudinal and behavioral scales). A pre-specified hierarchical multiple regression model was fitted. Block 1 (covariates) included gender, age, two education dummies (secondary and post-secondary; reference = ≤primary/no schooling), and monthly household expenditure (per 1,000 THB, approximately 29 USD). After an initial screening, age and secondary education were excluded, and gender, post-secondary education, and expenditure were retained in Block 1. Block 2 contained five determinants (knowledge, attitudes, perceived policy, perceived access to health resources, and exposure to health advice/support) and was estimated using Stepwise selection with Block 1 fixed. The final model explained 30.4% of the variance in COVID-19 preventive behaviors (R^2 = 0.304, adjusted R^2 = 0.293, ΔR^2 = 0.156; $p < 0.001$). Attitudes, perceived access, exposure to health advice/support, and post-secondary education emerged as significant positive predictors, whereas female gender and higher household expenditure were negatively associated with preventive behaviors; age and secondary education remained statistically non-significant after adjustment.

Keywords:
COVID-19 preventive behaviors, PRECEDE–PROCEED, Hmong ethnic group, Thailand

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an acute infectious illness caused by SARS-CoV-2, first reported in Wuhan in December 2019 and subsequently declared a Public Health Emergency of International Concern (PHEIC) on 30 January 2020 and a pandemic on 11 March 2020.[1] Even after the WHO's declaration that COVID-19 no longer constitutes the PHEIC status (May 2023), sustained preventive behaviors remain important during the post-pandemic transition.[2] Clinical severity ranges from mild respiratory symptoms to critical illness, with substantially higher risks of complications and mortality among older adults and those with underlying conditions.[3-4] Core public-health measures physical distancing, mask use, hand hygiene, vaccination, and adherence to health directivesremain essential for transmission control,[1,5] yet their effectiveness ultimately depends on population behavior.

The PRECEDE–PROCEED framework conceptualizes health behavior as shaped by predisposing (e.g., knowledge, attitudes), enabling (e.g., access to services and resources), and reinforcing (e.g., social and community support) factors operating within demographic and social contexts. This framework was selected because it offers a structured, theory-driven approach to examine the multi-domain determinants of preventive behaviors in community settings, where access to resources and social support are central to sustained practice.[6] In Thailand, increased COVID-19 knowledge is linked to more protective behaviors, and this knowledge tends to be greater among those with higher levels of education,[6] while cross-national studies highlight gendered patterns consistent with social norms, with women often exhibiting greater adherence.[8-9] In the post-pandemic phase, Thailand has adopted an endemic-oriented approach with risk-based management integrated into routine health services, underscoring the continued need for community-level prevention and communication.[10] System-level conditions including access to supplies and the preparedness of health systems also influence the sustainability of prevention behaviors,[11] as do advice and support from primary care and community networks.[12] Spatial inequities are also contributing factors rural areas frequently show lower adherence than urban settings[13] with these disparities amplified among ethnic-minority groups facing language, cultural, and service-access barriers.

In Thailand's northern highlands including Hmong communities geographic remoteness and language barriers constrain access to information and services and may undermine sustained preventive practices.[14-15] In Phayao Province, the COVID-19 cluster reported in 2021 among Hmong villages in Pong District was linked to community gatherings, prompting village-level control measures.[16] Local health statistics indicate that, in 2022, there were 4,664 Hmong residents across three villages in Khun Khuan Subdistrict of Pong District, underscoring the need to tailor communication and service delivery to community structure and reach.[17]

Despite a growing literature on determinants of COVID-19 preventive behaviors in general populations, empirical evidence for rural Hmong communities in Thailand remains limited. However, recent research from Thailand's post-pandemic "new normal" environment indicates that preventive practices continue to vary according to individual and contextual factors, underscoring the need to examine the determinants in underserved communities.[18] For example, evidence on theory-driven assessments of predisposing, enabling, and reinforcing factors in small rural ethnic communities during the post-pandemic transition remains limited. To

address this gap, this study applies the PRECEDE–PROCEED framework to examine how individual characteristics and predisposing, enabling, and reinforcing factors are associated with COVID-19 preventive behaviors among Hmong adults in Khun Khuan Subdistrict, Pong District, Phayao Province, with the goal of informing culturally and geographically appropriate health-promotion programs and service delivery.

MATERIALS AND METHODS

Design and setting

This analytical cross-sectional study examined the determinants of coronavirus disease 2019 (COVID-19) preventive behaviors among Hmong adults residing in Khun Khuan Subdistrict, Pong District, Phayao Province, Thailand. The study area was a rural highland setting in northern Thailand, characterized by geographic remoteness and dispersed households. A detailed map is not provided here to reduce the risk of indirect identification of a small community; instead, a contextual description is provided to support interpretation. The PRECEDE–PROCEED framework guided the specification of predisposing (e.g., knowledge, attitudes), enabling (e.g., access to health services and resources), and reinforcing (e.g., advice and social support) factors in relation to preventive behaviors. Data were collected from November 2022 to March 2023. Culturally sensitive procedures were applied during recruitment and interviews, and the interviewers were trained to use respectful, non-stigmatizing, locally appropriate communication techniques. To further minimize re-identification risk, this manuscript reports the study location only at the subdistrict and district levels, avoids granular geographic markers, reports aggregated results, and restricts raw data access to the research team.

Population and sample

The target population comprised Hmong residents aged ≥18 years living in villages 4, 7, and 9 of Khun Khuan Subdistrict (N = 3,282, per Khun Khuan Health Promoting Hospital records as of 10 January 2022).[19] The minimum sample was calculated using Daniel's formula for single-proportion estimation with finite population correction (95% confidence, Z=1.96; p=0.50; d=0.05), yielding n=344. After allowing 10% for non-response and incomplete data, the required sample was set at n = 379; a total of 402 participants were enrolled. Inclusion criteria were having Hmong ethnicity; age ≥18 years; being resident in villages 4, 7, or 9 for ≥6 months; having ability to communicate in Hmong or Thai; and providing written informed consent. Exclusion criteria were withdrawing during the data collection process or being inflicted with an illness severe enough to preclude participation in the interview at the time of the survey. Stratified simple random sampling was implemented with villages as strata and proportional allocation using the most recent household rosters maintained by the Health Promoting Hospital. One eligible adult per household was randomly selected using a pre-specified procedure. In cases of non-contact or refusal, replacements were selected from a pre-randomized reserve list within the same village stratum to preserve randomness and minimize substitution bias. The achieved stratum counts were village 4 (n = 135), village 7 (n = 146), and village 9 (n = 121), yielding a total sample of 402 participants.

Measures and instruments

A structured questionnaire grounded in the PRECEDE–PROCEED framework was employed to capture background characteristics and theory-based determinants of COVID-19 preventive behaviors. The instrument comprised seven sections: (1) Personal characteristics (11 items: gender, age, education, monthly household expenditure, and related demographics); (2) Knowledge of COVID-19 prevention (12 dichotomous items, Yes/No; total score 0–12) classified as low (≤7), moderate (8–9), and high (≥10); (3) Attitudes toward COVID-19 prevention (12 items, measured using a 4-point Likert scale ranging from 1=strongly disagree to 4=strongly agree), summarized as mean per item (1.00–4.00) and categorized as low (<2.80), moderate (2.80–<3.40), and high (≥3.40); (4) Perceived policy for COVID-19 prevention (4 items measured on a Likert scale with the same reporting and cut-points); (5) Perceived access to health resources (10 items measured on a Likert scale; same); (6) Exposure to health advice and support (10 items measured on a Likert scale; same); and (7) COVID-19 preventive behaviors (12 items measured on a 4-point Likert scale scored 0–3 per item), reported as mean per item (0.00–3.00) and classified as low (<1.80), moderate (1.80–<2.40), and high (≥2.40). Content validity was high (IOC=0.97; three expert reviewers). A pilot study with 30 participants indicated acceptable internal consistency: KR-20=0.82 for knowledge, and Cronbach's α=0.78, 0.79, 0.77, 0.78, and 0.80 for Sections 3–7 (all ≥0.70).

Statistical analysis

Analyses were conducted using IBM SPSS Statistics (Version 29). Descriptive statistics summarized all variables (frequencies, percentages, means, standard deviations, minima, and maxima). For inferential analysis, a pre-specified hierarchical multiple regression under the PRECEDE–PROCEED framework was used. Block 1 (covariates) was entered by using the Enter method and initially included gender (male=0, female=1), age (years), education coded with two dummies secondary=1 and post-secondary=1 (reference = no or primary education) and monthly household expenditure per 1,000 THB. In the initial screening, age and the secondary dummy were not significant; thus, the second-round specification retained gender, the post-secondary education dummy, and expenditure. Block 2 (theory-driven determinants) initially comprised five variables (knowledge, attitudes, perceived policy, perceived access, and exposure to health advice and support) and was examined via Stepwise selection with Block 1 variables fixed; three predictors (attitudes, perceived access, and exposure to health advice and support) were retained and re-estimated in the final Enter model. Bivariate screening used t-test (gender), one-way ANOVA with post hoc tests (education), and Pearson's product–moment correlations (continuous variables). Assumptions were met (Durbin–Watson, Kolmogorov–Smirnov/normal probability plots, linearity, homoscedasticity, VIF and tolerance). Results are reported as B, β, 95% CI (for B), p, R^2, Adjusted R^2, ΔR^2, and SEE, two-tailed $\alpha=0.05$.[20-21]

RESULTS

Participant characteristics

From the 402 Hmong adults who participated in this study, 51.7% were female and 48.3% male. The mean age was 39.2 ± 15.2 years (18–82). Educational attainment was as follows: 53.0% had no or primary education, 37.1% had secondary education, and 10.0% had achieved post-secondary (associate, undergraduate, or higher degrees) education. Mean monthly

household expenditure was 6,406.2 ± 4,671.7 THB (≈ 184.1 ± 134.2 USD). PRECEDE PROCEED indices indicated high knowledge (84.8%; mean 10.2 ± 1.0), while attitudes, perceived policy, perceived access, and exposure to health advice and support were at moderate levels (means 3.1 ± 0.3, 3.1 ± 0.3, 3.1 ± 0.3, and 3.1 ± 0.2, respectively, on a 1–4 scale). The outcome—preventive behaviors (item mean 0–3)—averaged 2.1 ± 0.4, indicating a moderate level overall (Table 1).

Table 1. Participants' demographic characteristics. (n=402)

Variables	Number	Percentage (%)
Gender		
Male	194	48.3
Female	208	51.7
Age		
18–34	179	44.5
35–59	158	39.3
≥ 60	65	16.2
Mean ± SD = 39.2 ± 15.2, Min = 18, Max = 82		
Education		
No or primary education	213	53.0
Secondary education	149	37.1
Post-secondary (associate/bachelor's or higher)	40	10.0
Monthly household expenditure (THB)		
≤ 5,000 (≤ 143.7 USD)	150	37.3
5,001 – 10,000 (143.7–287.4 USD)	241	60.0
≥10,001 (≥ 287.4 USD)	11	2.7
Mean ± SD (THB) = 6,406.2 ± 4,671.7, Min = 1,000, Max = 50,000		
Mean ± SD (USD) = 184.1 ± 134.2, Min = 28.7, Max = 1,436.8		
Knowledge of COVID-19 prevention		
Low level (score ≤ 7)	5	1.2
Moderate level (score 8–9)	56	13.9
High level (score ≥10)	341	84.8
Mean ± SD = 10.2 ± 1.0, Min = 2.0, Max = 12.0		
Attitudes toward COVID-19 prevention		
Low level (score <2.8)	3	0.7
Moderate level (score 2.8–<3.4)	342	85.1
High level (score ≥3.4)	57	14.2
Mean ± SD = 3.1 ± 0.3, Min = 2.7, Max = 4.0		
Policy support		
Low level (score <2.8)	48	11.9
Moderate level (score 2.8–<3.4)	296	73.6
High level (score ≥3.4)	58	14.4
Mean ± SD = 3.1 ± 0.3, Min = 2.0, Max = 4.0		
Perceived access to health resources		
Low level (score <2.8)	22	5.5
Moderate level (score 2.8–<3.4)	315	78.4
High level (score ≥3.4)	65	16.2
Mean ± SD = 3.1 ± 0.3, Min = 2.0, Max = 4.0		
Exposure to health advice and support		
Low level (score <2.8)	11	2.7
Moderate level (score 2.8–<3.4)	352	87.6

Variables	Number	Percentage (%)
High level (score ≥3.4)	39	9.7
Mean ± SD = 3.1 ± 0.2, Min = 2.3, Max = 4.0		
COVID-19 preventive behaviors		
Low level (score <1.8)	26	6.5
Moderate level (score 1.8–<2.4)	292	72.6
High level (score ≥2.4)	84	20.9
Mean ± SD = 2.1 ± 0.4, Min = 1.3, Max = 3.0		

Bivariate associations

Preventive behaviors correlated positively with education ($r = 0.156$, $p < 0.01$) and negatively with expenditure ($r = -0.285$, $p < 0.01$). Sociocognitive constructs were intercorrelated: attitudes with policy support ($r = 0.367$), perceived access ($r = 0.303$), and exposure to health advice and support ($r = 0.373$); policy support also correlated with perceived access ($r = 0.456$) (all $p < 0.01$). Age correlated negatively with education ($r = -0.584$, $p < 0.01$), reflecting cohort differences in schooling. Group comparisons indicated higher preventive-behavior scores among males vs females (t-test = 2.78, $p = 0.006$) and significant differences by education levels (ANOVA, $F(2,399) = 18.66$, $p < 0.001$), with the post-secondary group scoring higher than both the secondary and no or primary education groups (post hoc Tukey's HSD or Tamhane's T2, $p < 0.001$). Accordingly, Block-1 covariates for multivariable models were female gender (dummy), post-secondary education (dummy), and expenditure (per 1,000 THB; ≈ 29 USD). (Table 2).

Table 2. Bivariate correlation analysis of the relationship between independent variables (n = 402)

Factors	Age	Expenditure	Knowledge of COVID-19 prevention	Attitudes toward COVID-19 prevention	Policy support	Perceived access	Exposure to health advice and support	COVID-19 preventive behaviors
Age	1.000	0.137**	0.079	0.011	0.029	0.055	-0.073	-0.022
Expenditure		1.000	0.027	0.043	-0.002	-0.067	-0.017	-0.285**
Knowledge of COVID-19 prevention			1.000	0.104*	0.042	0.060	-.142**	-0.267**
Attitudes toward COVID-19 prevention				1.000	0.367**	0.303**	0.373**	0.113*
Policy support					1.000	0.456**	0.076	0.138**
Perceived access to health resources						1.000	0.152**	0.204**
Exposure to health advice and support							1.000	0.156**
Preventive behaviors								1.000

Pearson's r shown; two-tailed tests. * p<.05, ** p<.01.
Household expenditure per month (per 1,000 THB; ≈ 29 USD).

Categorical covariates analyzed separately: Sex (t-test = 2.78, p = 0.006), Education (one-way ANOVA, F = 18.66, p < 0.001; post-secondary > secondary and no or primary education).

Hierarchical multiple regression and model fit

With preventive behaviors (item mean 0–3) as the dependent variable, Block 1 entered the pre-screened covariates (gender, education, expenditure), followed by attitudes, perceived access, and exposure to health advice and support (Blocks 2–4). Model fit improved at each step: R^2 rose from 0.148 (Model 1) to 0.249 (ΔR^2 = 0.101), 0.290 (ΔR^2 = 0.041), and 0.304 (ΔR^2 = 0.014). All F-changes were significant (ΔF = 53.230, 22.755, 8.037; p ≤ 0.005). The final model yielded Adjusted R^2 = 0.293 and SEE = 0.334 (Table 3).

Table 3. Hierarchical multiple regression model fit predicting COVID-19 preventive behaviors

Factor	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change statistics				
					R Square Change	F Change	df 1	df 2	Sig. F Change
Model 1[a]	0.385	0.148	0.142	0.368	0.148	23.107	3	398	<0.001
Model 2[b]	0.499	0.249	0.241	0.346	0.101	53.230	1	397	<0.001
Model 3[c]	0.538	0.290	0.281	0.337	0.041	22.755	1	396	<0.001
Model 4[d]	0.551	0.304	0.293	0.334	0.014	8.037	1	395	0.005

Covariates entered a priori: sex (male = 0, female = 1); education coded with two dummies—secondary (1 = secondary; 0 = otherwise) and post-secondary (1 = post-secondary; 0 = otherwise), with no or primary education as the reference; expenditure (per 1,000 THB; ≈ 29 USD).

[a] Predictors: constant, sex, education (post-secondary), expenditure (per 1,000 THB; ≈ 29 USD).

[b] Predictors: constant, sex, education (post-secondary), expenditure (per 1,000 THB; ≈ 29 USD), attitudes toward COVID-19 prevention.

[c] Predictors: constant, sex, education (post-secondary), expenditure (per 1,000 THB; ≈ 29 USD), attitudes toward COVID-19 prevention, perceived access to health resources.

[d] Predictors: constant, sex, education (post-secondary), expenditure (per 1,000 THB; ≈ 29 USD), attitudes toward COVID-19 prevention, perceived access to health resources, exposure to health advice and support.

Final coefficients and prediction equation

In the final Enter model (Block 1 fixed; significant theory-based predictors retained), positive associations with preventive behaviors were observed for attitudes (B = 0.236, SE = 0.068, β = 0.177, p = 0.001; 95% CI 0.102–0.370), perceived access (B = 0.255, SE = 0.056, β = 0.207, p <0.001; 95% CI 0.145–0.365), and exposure to health advice and support (B = 0.230, SE = 0.081, β = 0.139, p = 0.005; 95% CI 0.070–0.389). Among the covariates, post-secondary education remained positively associated (B = 0.376, SE = 0.057, β = 0.284, p < 0.001; 95% CI 0.265–0.487), whereas household expenditure (per 1,000 THB, ≈ 29 USD) showed a negative association (B = −0.017, SE = 0.004, β = −0.205, p < 0.001; 95% CI −0.025–−0.010). Female gender had a small negative coefficient (B = −0.095, SE = 0.034, β = −0.120, p = 0.005; 95% CI −0.161–−0.029). Overall, attitudes, perceived access, exposure to health advice/support, and post-secondary education were significant positive predictors, whereas higher household expenditure and female gender were negatively associated with preventive behaviors in the adjusted model. VIFs < 1.5 indicated no concerning multicollinearity (Table 4).

Table 4. Final multiple regression model coefficients predicting COVID-1 9 preventive behaviors (n = 402)

Predictor	Unstandardized Coefficients		β	t	Sig.	95% Confidence Interval for B		VIF
	B	SE				Lower Bound	Upper Bound	
(Constant)	0.036	0.252	—	0.142	0.887	−0.460	0.532	—
Sex	−0.095	0.034	−0.120	−2.817	0.005	−0.161	−0.029	1.022
Education	0.376	0.057	0.284	6.659	<0.001	0.265	0.487	1.029
Expenditure	−0.017	0.004	−0.205	−4.806	<0.001	−0.025	−0.010	1.033
Attitudes toward COVID-19 prevention	0.236	0.068	0.177	3.466	0.001	0.102	0.370	1.473
Perceived access to health resources	0.255	0.056	0.207	4.565	<0.001	0.145	0.365	1.162
Exposure to health advice and support	0.230	0.081	0.139	2.835	0.005	0.070	0.389	1.364

Prediction equation and interpretation

Using unstandardized coefficients (B), the prediction model was:

BEHAV = 0.036 − 0.095(GENDER) + 0.376(EDU) − 0.017(EXP1000) + 0.236(ATT) +0.255(ACCESS) + 0.230(ADVSUP)

Where BEHAV = preventive-behavior score (item mean 0–3; higher = more behavior); GENDER = male 0, female 1; EDU = 1 if post-secondary; 0 if no or primary or secondary; EXP1000 = monthly household expenditure (per 1,000 THB; ≈ 29 USD); ATT = attitudes; ACCESS = perceived access to health resources; ADVSUP = exposure to health advice and support.

The final model explained 30.4% of the variance (Adjusted R^2 = 0.293). Modifiable predictors—attitudes, perceived access, and exposure to health advice and support—showed independent positive associations. Higher expenditure was modestly associated with lower preventive behaviors, and females scored slightly lower than males after adjustment.

DISCUSSION

Anchoring the analysis in the PRECEDE–PROCEED framework provided a theory-led structure for ordering the determinants and interpreting their incremental variance explained across blocks. Overall, post-secondary education, perceived access to health resources, attitudes, and exposure to health advice and support showed independent positive associations with COVID-19 preventive behaviors, whereas higher household expenditure and female gender were inversely related. Although the model's overall predictive power was modest, the identified determinants are best interpreted within the social and cultural context of rural Hmong communities, where constrained formal education, geographic distance from services, and language-mediated access to health information—often shaped through community-mediated information flow—may influence how prevention guidance is understood and enacted.[14] This demographic profile reflects a rural Hmong context characterized by low

formal education, moderate household income, and limited proximity to health services—factors that shape preventive behaviors through socio-structural access and capital gradients. These patterns align with evidence that structural inequities and socio-spatial isolation constrain COVID-19 preventive practices in rural settings[11,13] and are consistent with the PRECEDE PROCEED logic in which predisposing, enabling, and reinforcing conditions operate as layered determinants.[6] Importantly, in the post–COVID-19 period, preventive behaviors are increasingly sustained routines rather than short-term outbreak compliance; after disease reclassification and normalization, reductions in preventive behaviors and perceived risk have been observed in student populations, consistent with pandemic fatigue.[22] Within this structure, the hierarchical model accounted for a moderate share of variance in preventive behaviors ($R^2 = 0.304$; Adjusted $R^2 = 0.293$; SEE = 0.334; $p < 0.001$). Entering predictors in conceptually ordered blocks—personal → predisposing → enabling → reinforcing—yielded clear, theory-consistent gains in ΔR^2 with minimal multicollinearity (all VIFs < 1.5), consistent with PRECEDE–PROCEED applications using hierarchical regression.[5] Similar stepwise gains have been reported in PRECEDE applications for COVID-19 behaviors in school/community settings and in national web-based models.[23-25]

Personal factors. Among the covariates, post-secondary education showed the strongest independent association (β = 0.284). A plausible mechanism is that higher education is linked to better health literacy, which helps individuals interpret technical guidance and embed it in daily routines, which is consistent with Thai evidence linking higher COVID-19 knowledge/health literacy to better preventive behaviors[7,26-27] and qualitative accounts emphasizing language/context translation in ethnic communities.[14] Related work among rural older adults in northeastern Thailand also reports education-linked behavioral advantages,[28] while urban studies have connected health literacy and information access to preventive practice.[29] In contrast, female gender exhibited a small negative coefficient (β = −0.120). Although cross-national analyses often find higher adherence among women,[9] the direction here matches Thai reports[23] and is compatible with a "double-burden" hypothesis for rural ethnic women constrained time budgets and less access to formal channels due to care-work and income demands.[30-31] Although age correlated positively with behaviors at screening, it did not remain in the final model once other determinants were included, suggesting its influence is channeled through education and access.

Predisposing factors. Attitudes retained an independent positive association (β = 0.177), in line with behavioral theory whereby affective cognitive appraisals propel practice. Knowledge did not remain significant after full adjustment, a pattern also observed in PRECEDE-based analyses when other domains are considered,[24] even as broader KAP reports sometimes document direct knowledge–practice links.[32] In the post–COVID-19 period, attitudinal drivers may become more salient as preventive behaviors shift from outbreak-driven compliance to sustained routines. When perceived risk declines after reclassification and normalization, maintaining favorable attitudes may be important for sustaining preventive practices.[22] The implication is not to downplay knowledge, but to deliver bilingual, education-matched content so that its effect is translated via attitudinal appraisals—an approach repeatedly recommended for linguistically diverse groups.[14,33] Echoing this pathway, provincial evidence shows that income, risk perception, media perception, and attitudes

predict preventive behaviors,[34] while knowledge and media accessibility predicted both preventive practice and vaccination in rural northern Thailand.[35]

Enabling factors. Perceived access to health resources emerged as a systems lever (β = 0.207). When services, supplies, and communication channels were proximal and rural-friendly, health behaviors were more likely to be repeated and sustained— a finding that is consistent with previous research, which has highlighted the role of access as a precondition for continuity during and after outbreaks.[11] Evidence specifically from the Thai context further underscores how primary-care networks and village health volunteers (VHV) operationalize access in rural settings.[36] In the post-pandemic context, VHVs' functions as trusted community intermediaries may be particularly salient for ethnic and rural communities, helping translate guidance, facilitate linkage to services, and support community communication.[37] Meanwhile, household expenditure (per 1,000 THB; ≈ 29 USD) was negatively associated with behaviors (β = −0.205), suggesting a crowd-out effect from financial/time pressures, in line with socio-spatial inequities in adherence[13] and work linking economic stressors to the erosion of health behaviors.[38-39] Social support did not remain significant in multivariable models but correlated with attitudes and access in bivariate analysis, consistent with prior findings in the Thai context.[23]

Reinforcing factors. Exposure to health advice and support showed a positive effect (β = 0.139). This finding aligns with models emphasizing the parts played by social norms and community intermediaries in turning policy into everyday action, especially among older adults and populations with language constraints.[11-12,24,36] Thai and regional evidence highlights the roles of village health volunteers, peer leaders, and bilingual risk communication in migrant and ethnic groups.[15,33] In the post–COVID-19 period, reinforcement increasingly occurs within evolving information environments; trusted local actors (including VHVs) may reinforce preventive norms as protective practices are relaxed in the post-reclassification period.[22,37] Taken together, these patterns highlight modifiable predisposing, enabling, and reinforcing pathways that are amenable to multilevel interventions to strengthen COVID-19 preventive behaviors in rural ethnic settings.

Post–COVID-19 context: vaccination uptake and social media exposure. These findings should also be interpreted alongside vaccination uptake and information environments in Thailand. Vaccine acceptance and confidence have been shaped by perceived effectiveness, concerns about side effects, and trust in vaccine policy,[40] while exposure to vaccine information—including misinformation—has been associated with vaccine acceptance.[41] In parallel with this, Thailand-specific analyses show that COVID-19 infodemic dynamics on major social media platforms form networked ecosystems in which misinformation and counter-narratives coexist and may not be equally amplified, potentially complicating risk communication.[42] For rural Hmong communities, these dynamics may interact with language accessibility and community trust, resulting in reinforcing pathways being weakened if misinformation erodes confidence in or perceptions of the benefits of preventive behaviors.

Limitations and directions. This cross-sectional design precludes causal inference, while self-reported measures may introduce reporting bias. Future work should employ longitudinal and multilevel designs, incorporate community-level variables (language, norms, networks), and

experimentally compare bilingual, community-mediated messaging with standard communication while concurrently measuring household cost burdens.

CONCLUSION

In this rural Hmong context, the PRECEDE–PROCEED framework provided a theory-led structure to clarify the determinants of COVID-19 preventive behaviors. Post-secondary education had the largest influence, followed by perceived access, attitudes, and exposure to health advice and support; in contrast, higher household expenditure and female gender were associated with lower adherence. Programs should prioritize education-matched bilingual materials, expand near-home access to services and supplies (e.g., via village health volunteers), and provide repeated, community-based advice in order to sustain behaviors. Longitudinal and multilevel studies are warranted to test these mechanisms and strengthen generalizability.

RECOMMENDATIONS

Programs targeting rural Hmong and similar ethnic communities should translate these determinants into coordinated, multilevel strategies consistent with the PRECEDE–PROCEED framework. In the post–COVID-19 period, recommendations should emphasize sustaining feasible, routine preventive practices after reclassification and normalization rather than continuing with short-term outbreak compliance. Health authorities and primary care teams should embed bilingual (Hmong–Thai), education-matched communication within routine services and outreach, and link vaccination and screening with convenient access to protective supplies through village-based distribution and village health volunteers. To strengthen policy relevance, these communication activities should be institutionalized within routine service delivery to reduce reliance on ad hoc campaigns. Service schedules and delivery models should minimize indirect costs by aligning with local livelihoods and addressing the constraints faced by women. At the community level, engaging clan leaders, religious figures, and family networks can normalize protective behaviors and address information gaps and misconceptions in evolving social media environments. Programs should also strengthen vaccine confidence by addressing common concerns through trusted local channels and consistent messaging. Future initiatives should incorporate repeated behavioral measurement and, where feasible, longitudinal or multilevel designs to assess durability and scalability across other resource-constrained ethnic settings.

AUTHOR CONTRIBUTIONS

PS: Conceptualization, methodology, formal analysis, investigation, writing – original draft, writing – review & editing, project administration, supervision, and funding acquisition. NP: Investigation, data curation, and writing – review & editing. KS: Investigation, visualization, and writing – review & editing.

ETHICAL CONSIDERATIONS

The study protocol was approved by the Human Research Ethics Committee of the University of Phayao, Thailand (protocol no. UP-HEC 1.3/043/65; approval date 8 November 2022) in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants using bilingual materials and interpreter support as needed, and participation was voluntary with data anonymized before analysis.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest

REFERENCES

1. World Health Organization. Coronavirus disease (COVID-19) pandemic [Internet]. 2020 [cited 2025 Nov 9]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019
2. World Health Organization. Statement on the fifteenth meeting of the International Health Regulations (2005) Emergency Committee regarding the coronavirus disease (COVID-19) pandemic [Internet]. 2023 [cited 2026 Feb 7]. Available from: https://www.who.int/news/item/05-05-2023-statement-on-the-fifteenth-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-coronavirus-disease-(covid-19)-pandemic
3. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med. 2020; 382:1708-20. doi:10.1056/NEJMoa2002032
4. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395:1054-62. doi:10.1016/S0140-6736(20)30566-3
5. Centers for Disease Control and Prevention. How to protect yourself & others [Internet]. 2021 [cited 2025 Nov 9]. Available from: https://www.cdc.gov/covid/prevention/index.html
6. Green LW, Kreuter MW. Health program planning: an educational and ecological approach. 4th ed. New York: McGraw-Hill; 2005.
7. Ounsaneha W, Laosee O, Suksaroj TT, Rattanapan C. Preventive behaviors and influencing factors among Thai residents in endemic areas during the highest epidemic peak of the COVID-19 outbreak. Int J Environ Res Public Health. 2023;20:2525. doi:10.3390/ijerph20032525
8. Galasso V, Pons V, Profeta P, Becher M, Brouard S, Foucault M. Gender differences in COVID-19 attitudes and behavior: panel evidence from eight countries. Proc Natl Acad Sci U S A. 2020;117:27285-91. doi:10.1073/pnas.2012520117
9. Jayawardana S, Esquivel M, Orešković T, Mossialos E. Gender differences in COVID-19 preventative measures and vaccination rates in the United States: a longitudinal survey analysis. Vaccine. 2024;42:126044. doi:10.1016/j.vaccine.2024.06.012
10. Strategy and Planning Division, Office of the Permanent Secretary, Ministry of Public Health (Thailand). Plan and measures for managing the COVID-19 situation towards endemic disease (Endemic Approach to COVID-19). 1st ed. Nonthaburi: Office of the Permanent Secretary, Ministry of Public Health; 2022.

11. Pujolar G, Oliver-Anglès A, Vargas I, Vázquez ML. Changes in access to health services during the COVID-19 pandemic: a scoping review. Int J Environ Res Public Health. 2022; 19:1749. doi:10.3390/ijerph19031749
12. Xue B, Wu Y, Zheng X, Xue Y, Dong F, Xiao S, et al. Effects of information sources on public preventive behaviors in health emergencies: evidence from a digital epidemiologic study during the COVID-19 pandemic. Front Public Health. 2022;10:981649. doi:10.3389/ fpubh.2022.981649
13. Callaghan T, Lueck JA, Trujillo KL, Ferdinand AO. Rural and urban differences in COVID-19 prevention behaviors. J Rural Health. 2021;37: 287-95. doi:10.1111/jrh.12556
14. Kitchanapaibul S, Udplong A, Apidechkul T, Tamornpark R, Mulikaburt T, Srichan P, et al. Experiences and expectations regarding COVID-19 prevention and control among hill tribe populations in northern Thailand: a qualitative study. BMC Public Health. 2021;21:1060. doi:10.1186/s12889-021-11145-5
15. Wongnuch P, Mulikaburt T, Apidechkul T, Srichan P, Tamornpark R, Udplong A, et al. Acceptance and accessibility to the early phase COVID-19 vaccination among healthcare workers and the hill tribe population in Thailand. Sci Rep. 2022;12:11035. doi:10.1038/s41598-022-15149-y
16. Matichon Online. COVID-19 cluster in Pong District's Hmong villages; two villages closed, 84 new cases [in Thai] [Internet]. 2021 [cited 2025 Nov 9]. Available from: https://www.matichon.co.th/region/news_3038071
17. Health Data Center, Ministry of Public Health. Population of Hmong residents in Khun Khuan Subdistrict, Pong District, Phayao Province (FY 2022) [dataset] [Internet]. 2022 [cited 2025 Nov 9]. Available from: https://hhdclampang.anamai.moph.go.th:8080/hhdcdashboard/ethnics/default/mooban?tb=560607
18. Kaewchutima N, Precha N, Duangkong N, Jitbanjong A, Dwipayanti NMU. Knowledge and practice of facemask disposal among university students in Thailand: A new normal post the COVID-19 pandemic. PLoS One. 2023;18(4):e0284492. doi:10.1371/journal.pone.0284492.
19. Khun Khuan Health Promoting Hospital. Annual health service report of Khun Khuan Subdistrict. Phayao, Thailand: Khun Khuan Health Promoting Hospital; 2022.
20. Cohen J, Cohen P, West SG, Aiken LS. Applied multiple regression/ correlation analysis for the behavioral sciences. 3rd ed. Mahwah, NJ: Lawrence Erlbaum; 2003.
21. Field A. Discovering statistics using IBM SPSS statistics. 4th ed. London: Sage; 2013.
22. Ouchi Y, Morioka I. Preventive behaviours and perceptions regarding COVID-19 after its reclassification among Japanese medical university students. Thai J Public Health. 2024;54(3):986-999.
23. Rojpaisarnkit K, Kaewpan W, Pengpid S, Peltzer K. COVID-19 preventive behaviors and influencing factors in the Thai population: a web-based survey. Front Public Health. 2022;10: 816464. doi:10.3389/fpubh.2022. 816464
24. He YY, Huang WH, Tung CY. A cross-sectional study applying the PRECEDE model to explore factors influencing epidemic prevention behaviors among preschool educators. BMC Public Health. 2024;24:3486. doi:10.1186/s12889-024-20865-3
25. Xie YJ, Tian L, Deng Y, Yang L, Cheung K, Li Y, et al. Use of the PRECEDE–PROCEED model in piloting vaccine promotion and infection self-protection: intervention

development and effectiveness examination. Vaccines (Basel). 2024; 12:979. doi:10.3390/vaccines 12090979
26. Saisanan Na Ayudhaya W, Thanapop C, Wongrith P, Loonlawong S, Laor K, Fajriyah R. Health literacy and preventive behaviors towards COVID-19 among village health volunteers and residents in urban and rural areas of upper southern Thailand. Soc Sci. 2023;12:377. doi:10.3390/socsci1207 0377
27. Chamnankit T, Ong-Artborirak P, Boonchieng W, Songsin P, Kingkaew WM, Siladlao S, et al. Health literacy and coronavirus disease 2019 prevention behaviors of village health volunteers in Samut Songkhram Province, Thailand. J Public Health Dev. 2023;21:55-65. doi:10.55131/ jphd/2023/210305
28. Maleelai K, Phudket N, Rittiron P. Behavior to prevent coronavirus disease 2019 (COVID-19) among the elderly with non-communicable disease in rural northeastern Thailand. J Health Sci Med Res. 2024;42: e20241046. doi:10.31584/jhsmr. 20241046
29. Pechrapa K, Yodmai S, Kittipichai W, Charupoonpol P, Suksatan W. Health literacy among older adults during COVID-19 pandemic: a cross-sectional study in an urban community in Thailand. Ann Geriatr Med Res. 2021;25:309-17. doi:10.4235/agmr. 21.0090
30. CARE; UN Women. The COVID-19 outbreak and gender: key advocacy points from Asia and the Pacific [Internet]. 2020 [cited 2025 Nov 9]. Available from: https://asiapacific. unwomen.org/en/digital-library/ publications/2020/03/the-covid-19-outbreak-and-gender
31. UN Women. Against the odds: stories from women in Thailand during COVID-19 [Internet]. 2020 [cited 2025 Nov 9]. Available from: https://thailand.un.org/en/51835-against-odds-stories-women-thailand-during-covid-19
32. Al-Hanawi MK, Angawi K, Alshareef N, Qattan AMN, Helmy HZ, et al. Knowledge, attitude and practice toward COVID-19 among the public in the Kingdom of Saudi Arabia: a cross-sectional study. Front Public Health. 2020;8:217. doi:10.3389/fpubh.2020. 00217
33. Kosiyaporn H, Julchoo S, Papwijitsil R, Uansri W, Phaiyarom K, Sinam S, et al. Risk communication distributed among migrant workers during the COVID-19 crisis in Thailand: analysis on structural and networking gaps. Trop Med Infect Dis. 2022;7:296. doi:10.3390/tropicalmed7100296
34. Poonaklom P, Rungram V, Abthaisong P, Piralam B. Factors associated with preventive behaviors towards coronavirus disease (COVID-19) among adults in Kalasin Province, Thailand, 2020. Outbreak Surveill Investig Response J. 2020;13:78-89. doi:10.59096/osir.v13i3.262803
35. Pothisa T, Ong-Artborirak P, Seangpraw K, Tonchoy P, Kantow S, Auttama N, et al. Knowledge of COVID-19 and its relationship with preventive behaviors and vaccination among adults in northern Thailand's community. Int J Environ Res Public Health. 2022;19:1521. doi:10.3390/ ijerph19031521
36. Nawsuwan K, Oupra S, Singweratham P, Thepaksorn W. Uncovering the underlying aspects of successful COVID-19 prevention and control in Thailand through factor analysis: lessons we have not yet learned from village health volunteers. Belitung

Nurs J. 2023;9:505-11. doi:10.33546/bnj.2735
37. Nak-Ai W, Kitphati R, Wicharit L, Suphaudomphon T, Khotmanee S, Chantachon S. Kinship and containment: a qualitative study of village health volunteers' roles in community-based COVID-19 response in Thailand. Open Public Health J. 2025;18:e18749445403996. doi:10.2174/0118749445403996250829201101
38. Bazzoli A, Probst TM, Lee HJ. Economic stressors, COVID-19 attitudes, worry, and behaviors among U.S. working adults: a mixture analysis. Int J Environ Res Public Health. 2021;18:2338. doi:10.3390/ijerph18052338
39. Moon K, Heo W, Lee JM, Grable JE. Financial stress and COVID-19: a comprehensive analysis of the factors associated with the pandemic. Risks. 2023;11:218. doi:10.3390/risks11120218
40. Ngamchaliew P, Kaewkuea N, Nonthasorn N, Vonnasrichan T, Rongsawat N, Rattanachai L, et al. Acceptance of COVID-19 vaccination and vaccine confidence levels in Thailand: a cross-sectional study. Vaccine. 2023 Oct 20;41(44):6589-6598. doi:10.1016/j.vaccine.2023.09.018
41. Kosiyaporn H, Netrpukdee C, Pangkariya N, Chandrasiri O, Tangcharoensathien V. The impact of vaccine information and other factors on COVID-19 vaccine acceptance in the Thai population. PLoS One. 2023;18(3):e0276238. doi:10.1371/ournal.pone.0276238.
42. Kitikamdhorn A, Ramasoota P. COVID-19 infodemic on Facebook: a social network analysis in Thai context. Rev Commun. 2023;23(3):183-209. doi:10.1080/15358593.2022.2142067