Health Literacy and Associated Factors Influencing Pesticide Protective Behaviors Among Cassava Farmers in an Eastern Thailand Province: A Cross-Sectional Study

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Abstract: Pesticide exposure is a significant occupational hazard among cassava farmers, raising various health and environmental concerns. Health literacy plays a crucial role in enabling farmers to understand and implement effective pesticide protective behaviors. This cross-sectional study examined health literacy and factors influencing pesticide protective behavior among cassava farmers. The participants were 399 cassava farmers registered as growers in one province in eastern Thailand, aged 20-65. They had at least one year of experience using chemical pesticides in cassava cultivation. Data were collected using structured questionnaires from December 2024 to January 2025. Instruments were comprised of the Individual and Health Factors, Pesticide Usage Factors, Health Literacy on Pesticide Use, and Pesticide Protective Behaviors Questionnaires. Data analysis was conducted through descriptive statistics and multiple logistic regression techniques.

The findings indicated that the majority of cassava farmers possessed a moderate level of overall health literacy (48.1%) and exhibited pesticide protective behaviors (57.6%). A statistically significant positive relationship was observed between health literacy and pesticide protective behavior. Factors significantly associated with pesticide protective behaviors among cassava farmers included health literacy, age, education level, monthly income, allergic reactions from pesticide use, and duration of pesticide use, with health literacy being the strongest predictor. This study demonstrates that health literacy is crucial for enhancing pesticide protective behaviors. Nursing interventions should focus on educational strategies that enhance health literacy to promote safer pesticide practices, as well as the need for public health policies that support health literacy in agricultural safety programs, to safeguard the health of farming communities.

Keywords: Agricultural worker, Cassava, Farmers, Health literacy, Pesticides, Protective behavior

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Introduction

Over 30 million people in Thailand work in farming as their primary occupation, making it the main source of income for many rural households.[1] Thailand is a major agricultural country where the use of chemical pesticides is widespread across various crop production systems.[2] Although pesticides increase crop yields, their use has led to significant public health problems.[3] Exposure to pesticides causes acute symptoms such as skin and eye irritation and respiratory issues, as well as long-term risks including neurological disorders and chronic diseases.[4] In particular, cassava farming—a key economic crop, especially in eastern Thailand—exposes farmers to high levels of pesticides due to the insufficient use of personal protective equipment (PPE) and a limited understanding of safe pesticide practices.[5] In 2019, the Division of Occupational and Environmental Diseases reported 3,067 cases of occupational diseases related to pesticide exposure among agricultural workers. This resulted in an incidence rate of 21.6 cases per 100,000 workers and more than 400 fatalities.[6] Data from the previous three years show an annual average of over 4,000 pesticide poisoning cases, with an average rate of 28.2 cases per 100,000 workers.[6] Furthermore, national health screenings in 2023 reported that about 41% of farmers were classified as at risk or in unsafe health status due to pesticide exposure.[7,8]

Previous studies and national efforts have aimed to address pesticide-related health risks through guidelines on pesticide use and public awareness campaigns.[9,10] The Thai Pesticide Alert Network has identified cassava farmers as among the highest users of hazardous pesticides.[11] Health risk screenings, including blood cholinesterase monitoring and symptom assessments, confirm a rising trend of unsafe pesticide exposure despite these interventions.[7,8] However, unsafe pesticide handling practices remain common, particularly in rural communities.[12,13] One major cause of this issue is the low health literacy (HL) among cassava farmers, which affects their ability to access, understand, and apply health information about the safe use of pesticides.[14] Existing research[15-17] has focused on exposure levels and health outcomes, whereas few studies have thoroughly investigated HL and other factors influencing pesticide protective practices in this population. This study aimed to fill this gap by examining how HL affects pesticide protective behavior and the factors influencing pesticide protective behaviors (PPB) among cassava farmers. The findings will inform the development of targeted training and educational programs aimed at reducing pesticide-related health risks.

Conceptual Framework and Literature Review

This study was guided by the concept of HL proposed by Nutbeam[14] and the literature review.[8,9] As noted by Nutbeam, HL encompasses the cognitive and social skills that influence an individual's motivation and ability to access, understand, and apply information effectively to support and maintain their health.[14] HL is conceptualized as a personal asset that supports empowerment in health decision-making and behavioral change, and is categorized into three levels: Functional health literacy involves basic reading and writing skills needed to understand health information. Interactive HL encompasses advanced cognitive and social skills that enable individuals to communicate effectively with healthcare providers and interpret and apply information in daily life. Critical HL is the highest level, involving critical analysis of information and the ability to exert greater control over life events and health-related decisions.[14] Applying Nutbeam's Model[14] in this study, health literacy refers specifically to pesticide-related HL, which encompasses farmers' ability to access, understand, evaluate, and apply information related to the safe use, handling, and storage of pesticides.

PPB refers to the actions and practices that individuals, especially agricultural workers, adopt to reduce their exposure to pesticides and the associated health risks.[10,11] These behaviors include using PPE, following proper procedures for pesticide handling and application, safely storing and disposing of chemicals, and seeking medical attention if symptoms of pesticide exposure arise.[18,19] Employing Nutbeam's model, PPB occurs at three levels of HL.[14] At the functional level, individuals can understand labels and follow safety instructions. The interactive level involves using communication and problem-solving skills to modify behaviors. At the critical level, individuals critically assess risks and take proactive actions, such as advocating for safer environments.[14] Several studies conducted across different countries consistently demonstrate a positive correlation between HL and PPB. Research indicates that individuals with higher levels of HL regarding pesticide risks and safety measures are more likely to engage in protective behaviors.[20-22] This body of evidence suggests that pesticide-related HL is a critical determinant in reducing adverse health effects associated with pesticide exposure.

Previous research has assessed the relationship between HL and PPB. Still, few have specifically addressed pesticide-related health literacy—the ability to access, understand, evaluate, and apply safety information about pesticides.[12,14] This issue is particularly significant in Thai agricultural communities, where pesticide use is prevalent but protective practices are still insufficient.[18,19] Understanding the connection between HL and PPB can help identify barriers to safe practices. To provide a more comprehensive perspective, these influencing factors can be categorized into four groups: personal factors, health factors, pesticide usage factors, and health literacy on PPB. Demographic characteristics, such as age, education, income, and farming experience, are key personal factors that influence PPB.[13,15,20] Health-related experiences, including illnesses resulting from pesticide exposure or access to chemical testing, may increase risk awareness and encourage the adoption of protective behaviors.[8,9] Pesticide usage factors, such as training, access to PPE, and attitudes toward pesticide safety, also play a significant role in shaping behavior.[2]

Study Aims

This research aimed to 1) assess the levels of HL on pesticide protective behavior and pesticide protective behaviors, 2) examine the association between HL and PPB, and 3) examine the predictability of individual factors (sex, age, marital status, education level, monthly income), health factors (health problems, history of pesticide-related illness, access to blood chemical testing), pesticide usage factors (reason for pesticide use, training in pesticide application, duration of pesticide use, frequency of spraying per month, duration per spraying session, allergic reactions from pesticide use), and HL on pesticide protective behavior among cassava farmers in a province in the East of Thailand.

Methods

Design: This study utilized a cross-sectional design, and we have reported our findings according to the STROBE Statement Checklist.[23]

Sampling and Setting: This study was conducted in a province in the East of Thailand, where cassava is the primary economic crop. This area was purposefully selected due to its intensive agricultural practices and heavy reliance on chemical pesticides, which pose significant health risks to farmers. The exact population size was not known. The total population of cassava farmers in this province cannot be accurately counted due to outdated records and the presence of unregistered farmers, particularly smallholder or subsistence farmers. The confidence level for this study was set at 95.0% ($Z = 1.96$). The proportion of individuals exhibiting good PPB was 0.446[9] with an allowance for error (d) of 0.05. After performing the necessary calculations, the initial sample size of 380 individuals was increased by 5.0% to account for potential errors during data collection. Accordingly, 399 individuals were included as the final sample for this study.

The recruitment process started with applying specific inclusion and exclusion criteria. Eligible participants were individuals aged 20 to 65 years who were registered as cassava growers and had at least one year of experience using pesticides in cassava cultivation. Exclusion criteria included individuals with severe illnesses or conditions that could hinder participation, those who had moved out of the area, ceased farming activities during the data collection period, or had communication difficulties.

To minimize selection bias, participants were chosen using a multi-stage random sampling method consisting of two steps. First, the nine provincial districts were narrowed down by randomly selecting three districts using a simple random sampling technique, conducted by lottery without replacement. Next, within the selected districts, simple random sampling was conducted by drawing lots without replacement from the official, registered list of cassava farmers in the province.[24] This resulted in obtaining 145, 140, and 142 individuals from the first, second, and third districts, respectively. Thus, the potential participants were 429. However, 133 individuals met the inclusion criteria and remained in each district, while the others were excluded due to not meeting the inclusion criteria, declining to participate because of scheduling conflicts, illness, or reluctance, or being unavailable or choosing not to participate in the study. Ultimately, the study comprised 399 participants.

Ethical Considerations: The study protocol received approval from the Institutional Review Board (IRB) of Valaya Alongkorn Rajabhat University under Royal Patronage (IRB No: 0078/2024), with certification granted on December 13, 2024. The authors confirmed that all participants received written information about the study's objectives, procedures, risks, and benefits. Participation was voluntary, with the right to withdraw at any time. All participants signed a written informed consent form to ensure their rights and confidentiality were protected.

Instruments: All four questionnaires were developed by the principal investigator (PI), and the tools' validity was evaluated by three experts: an environmental health professional, a public health specialist, and a health behavior expert, who validated the content validity using the Index of Item-Objective (IOC).

The Individual and Health Factors Questionnaire. The questionnaire includes eight items related to individual and health factors, presented in both open-ended and closed-ended formats. It covers sex, age, education level, monthly income, marital status, health issues, history of pesticide-related illnesses, and access to blood chemical testing services. The IOC for this section was 0.92.

The Pesticide Usage Factors Questionnaire. This part was developed to assess factors related to pesticide usage. The questionnaire includes seven items, presented in both open-ended and closed-ended formats, including the reason for pesticide use, training in pesticide application, duration of pesticide use, frequency of spraying per month, duration of each spraying session, types of pesticides used, and allergic reactions experienced from pesticide use. The IOC was 0.90.

The Health Literacy on Pesticide Protective Behavior Questionnaire. This tool was developed based on Nutbeam's concept of HL and a literature review.[8,14] This comprises 50 items covering six dimensions. The cognitive aspect comprises 13 yes/no questions that assess knowledge about pesticide use. Each accurate answer earned 1 point, whereas incorrect answers received 0 points. Based on Bloom's criteria,[25] scores are categorized as high (11-13 points: > 80%), moderate (8-10 points: 60-79%), or low (0-7 points: < 60%). The remaining five dimensions—access to information and services (7 items), communication (8 items), self-management (6 items), critical media literacy (6 items), and decision-making (10 items)—are assessed using a 5-point frequency scale, rating on the often they performed relevant behaviors: regularly (7 days/week) = 5, frequently (5–6 days/week) = 4, sometimes (3–4 days/week) = 3, infrequently (1–2 days/week) =2, or never (0 days/week) = 1, while negative items are reverse-scored. According to Best's criteria,[26] mean scores can be classified as high (3.67–5.00), moderate (2.34–3.66), or low (1.00–2.33). The total HL on pesticide protective behavior score, calculated across all 50 items, ranged from 37 to 198 points, with the same classification thresholds applied to the overall mean score. An example item from this part is: "*You regularly observe any unusual health symptoms that may result from pesticide use.*" The validity of this instrument was confirmed with an IOC of 0.93. Reliability was assessed through both the pilot and the main study. The pilot study included 30 cassava farmers from the same provinces as the study sample, but they were not part of the sample. The Kuder-Richardson 20 (KR-20) coefficient for the cognitive aspect of the HL on pesticide protective behavior assessment reported at 0.92 in the pilot study and 0.94 in the main study. Additionally, Cronbach's alpha coefficients for HL on pesticide protective behavior regarding access to information and services, communication, self-management, critical media literacy, and decision-making were 0.90, 0.92, 0.89, 0.94, and 0.93, respectively, in the pilot study, and 0.95, 0.96, 0.94, 0.94, and 0.96, respectively, in the main study.

The Pesticide Protective Behaviors Questionnaire. This includes 30 items assessing farmers' pesticide-related practices, divided into three stages: preparation before pesticide use (10 items), pesticide application (9 items), and post-use activities (11 items). Responses are assessed using a 5-point frequency scale, rating on the often they performed relevant behaviors: regularly (7 days/week) = 5, frequently (5–6 days/week) = 4, sometimes (3–4 days/week) = 3, infrequently (1–2 days/week) = 2, or never (0 days/week) = 1, while negative items are reverse-scored. Using Best's criteria,[26] mean scores are interpreted as follows: 3.67–5.00 indicated a high level of PPB, 2.34–3.66 indicated a moderate level, and 1.00–2.33 indicated a low level. The overall PPB score, which ranges from 30 to 150 points, is calculated by averaging across all items and categorized into these three levels accordingly. An example item from this part is: "*You check the condition of the nozzle, spray hose, chemical tank, and related equipment before each use.*" The validity of this instrument was confirmed with an IOC of 0.91. Reliability was assessed through both the pilot study and the main study. The pilot study included 30 cassava farmers from the same provinces as the study sample, but they were not part of the sample. Cronbach's alpha coefficient for the PPB questionnaire was 0.92 in the pilot study and 0.95 in the main study.

Data Collection: The PI sent a letter to each district's health promotion hospital requesting permission to collect data. At the beginning of the research, the PI explained the objectives, procedures, and steps for data collection to the health promotion hospitals and village health volunteers. To control for information bias, the PI provided training for the research assistants to ensure they understood how to use the research tools properly, in accordance with fieldwork standards. The PI and ten research assistants conducted the sampling, obtained consent, and collected the research data. Participants voluntarily agreed to participate and signed informed consent forms. The PI and assistants then commenced data collection by administering questionnaires through face-to-face interviews conducted at participants' homes or designated community gathering areas within the villages between December 2024 and January 2025. Each interview took approximately 45 minutes per participant.

Data Analysis: This was performed utilizing IBM SPSS version 29.0.1 (IBM Corp.), with a significance threshold established at 0.05. Descriptive statistics were performed to characterize the sample, including number, percentage, mean, and standard deviation (SD). The Kolmogorov–Smirnov test was employed to evaluate the normal distribution of continuous variables. The results indicated that all variables followed a normal distribution ($p > 0.05$). For the second objective, Pearson's correlation coefficient was used to assess the association between HL and PPB, with both variables treated as continuous (interval scale). For the third objective, both HL and PPB were initially classified into three levels (high, moderate, and low) based on Best's criteria.[26] To meet the assumptions and improve the statistical power of logistic regression analysis, HL and PPB were later dichotomized into two groups: high versus low/moderate. This recording allowed for clearer interpretation and ensured a sufficient sample size per group for analysis. Before conducting multiple logistic regression (MLR), key assumptions were tested and satisfied. These included the absence of multicollinearity (with all variance inflation factors, VIFs, less than 2.0) and the appropriateness of the binary outcome variable. Variables were entered into the regression models using the Enter method. Results were reported as crude odds ratios (COR) obtained from binary logistic regression (BLR) and adjusted odds ratios (AOR) obtained from MLR, with corresponding 95% confidence intervals (CI).

Results

Individual characteristics and health factors

The analysis of individual and health-related factors is summarized in **Table 1**. The sample consisted predominantly of males (77.9%), with a mean age of 54.1 years (SD = 11.8). Most participants were married (75.2%), had completed primary education (58.6%), and earned an average monthly income of 5,000 Thai baht, approximately 153.0 USD (SD = 6,557.6 Thai baht or approximately 200.1 USD). Regarding health conditions, 55.1% reported having underlying diseases, with hyperlipidemia (32.6%) and hypertension (23.3%) being the most common. Additionally, 39.3% had a history of pesticide-related illness, 33.1% had accessed blood chemical testing, and 24.3% reported allergic reactions from pesticide exposure (**Table 1**).

Table 1. The number and percentage of the sample by individual and health factors (n = 399)

Variables	n	%
Sex		
Male	311	77.9
Female	88	22.1
Age (years)		
20-59	261	65.4
60 or above	138	34.6
(mean ± SD = 54.1 ± 11.8), Min-Max = 20-78		
Marital status		
Married	300	75.2
Single	75	18.8
Widowed/Divorced/Separated	24	6.0
Education level		
Primary school	234	58.6
Secondary school	144	36.1
Diploma degree or higher	21	5.3
Monthly income		
0-5,000 Thai baht (0-153 USD)	127	31.8
> 5,000 Thai baht (>153 USD)	272	68.2
(mean ± SD = 7,354.5 ± 6,557.6 Thai baht or 224.4 ± 200.1 USD), Min-Max = 0-100,000 Thai baht (0-3,051.6 USD)		

Table 1. The number and percentage of the sample by individual and health factors (n = 399) (Cont.)

Variables	n	%
Health problems		
No	179	44.9
Yes	220	55.1
History of pesticide-related illness		
No	242	60.7
Yes	157	39.3
Access to blood chemical testing services		
No	267	66.9
Yes	132	33.1

Note. Data are expressed as mean ± standard deviation or n (%). SD = Standard deviation

Pesticide usage factors

The analysis of pesticide usage factors is presented in **Table 2.** Most participants were hired to spray pesticides (76.7%) and had used pesticides for an average of 9.4 years (SD = 7.1). Over half (58.9%) used pesticides more than twice a month, typically for 1–2 hours per session (58.2%). About 44.9% received pesticide application training. The most commonly used pesticides included abamectin, fipronil, and diazinon, while glyphosate was the most frequently used herbicide. Reported allergic reactions included skin irritation (6.0%), respiratory symptoms (5.5%), and nausea or dizziness (5.0%) (**Table 2**).

Table 2. The number and percentage of the sample by pesticide usage factors (n = 399)

Variables	n	%
Reason for pesticide use		
Hired to spray pesticides	93	23.3
Personally spray pesticides	306	76.7
Training in pesticide application		
No	220	55.1
Yes	179	44.9
Duration of pesticide use		
1-5 years	92	23.1
6 years or more	307	76.9
(mean ± SD = 9.4 ± 7.1), Min-Max = 0-38		
Frequency of spraying per month (time)		
1-2	164	41.1
> 2	235	58.9
Duration per spraying session (hours per session)		
1-2	232	58.2
> 2	167	41.8
Types of pesticide use		
Pesticides		
Fipronil	150	37.6
Abamectin	179	44.9
Diazinon	66	16.5

Table 2. The number and percentage of the sample by pesticide usage factors (n = 399) (Cont.)

Variables	n	%
Herbicides		
Glufosinate	147	36.8
Glyphosate	236	59.1
Dinitroaniline	93	23.3
Allergic reactions from pesticide use		
Yes	97	24.3
No	302	75.7

Note. Data are expressed as mean ± standard deviation or n (%). SD = Standard deviation

Health literacy on pesticide protective behavior and pesticide protective behaviors

The analysis of HL among cassava farmers is summarized in **Table 3**. Most participants had low cognitive skills (66.4%) but demonstrated moderate levels in access to information (61.4%) and communication (54.1%). High levels were observed in self-management (57.1%), critical media literacy (48.8%), and decision-making (48.6%). Overall, the majority had a moderate level of HL (48.1%), followed by high (33.1%) and low levels (18.8%). Additionally, the analysis of PPB across three stages—before, during, and after pesticide use—is presented in **Table 3**. In all stages, the majority of participants demonstrated a moderate level of PPB. Overall, most had a moderate level of PPB (57.6%), followed by high (34.8%) and low (7.5%) levels.

Table 3. The number and percentage of sample by health literacy aspects and pesticide protective behaviors (n = 399)

Variables	n	%
Health literacy on pesticide protective behavior		
Cognitive (points)		
Low (0-7)	265	66.4
Moderate (8-10)	93	23.3
High (11-13)	41	10.3
(mean ± SD = 6.9 ± 2.7), Min-Max = 0-13		
Access to information and services (points)		
Low (mean 1.00-2.33)	46	11.5
Moderate (mean 2.34-3.66)	245	61.4
High (mean 3.67-5.00)	108	27.1
(mean ± SD = 23.1 ± 6.2), Min-Max = 9-35		
Communication (points)		
Low (mean 1.00-2.33)	25	6.3
Moderate (mean 2.34-3.66)	216	54.1
High (mean 3.67-5.00)	158	39.6
(mean ± SD = 28.6 ± 6.8), Min-Max = 13-40		
Self-management (points)		
Low (mean 1.00-2.33)	13	3.3
Moderate (mean 2.34-3.66)	158	39.6
High (mean 3.67-5.00)	228	57.1
(mean ± SD = 22.1 ± 4.5), Min-Max = 9-30		

Table 3. The number and percentage of sample by health literacy aspects and pesticide protective behaviors (n = 399) (Cont.)

Variables	n	%
Critical media literacy (points)		
Low (mean 1.00-2.33)	31	7.8
Moderate (mean 2.34-3.66)	173	43.4
High (mean 3.67-5.00)	195	48.8
(mean ± SD = 21.4 ± 5.1), Min-Max = 6-30		
Decision-making (points)		
Low (mean 1.00-2.33)	20	5.0
Moderate (mean 2.34-3.66)	185	46.4
High (mean 3.67-5.00)	194	48.6
(mean ± SD = 36.7 ± 7.8), Min-Max = 12-50		
Overall health literacy (points)		
Low (mean 1.00-2.33)	75	18.8
Moderate (mean 2.34-3.66)	192	48.1
High (mean 3.67-5.00)	132	33.1
(mean ± SD = 140.0 ± 26.4), Min-Max = 65-198		
Pesticide protective behaviors		
Preparation for pesticide use (points)		
Low (mean 1.00-2.33)	31	7.8
Moderate (mean 2.34-3.66)	278	69.7
High (mean 3.67-5.00)	90	25.5
(mean ± SD = 31.9 ± 7.2), Min-Max = 18-50		
During pesticide spraying (points)		
Low (mean 1.00-2.33)	45	11.3
Moderate (mean 2.34-3.66)	251	62.9
High (mean 3.67-5.00)	103	25.8
(mean ± SD = 21.4 ± 6.3), Min-Max = 11-35		
After pesticide use (points)		
Low (mean 1.00-2.33)	26	6.5
Moderate (mean 2.34-3.66)	272	68.2
High (mean 3.67-5.00)	101	25.3
(mean ± SD = 44.4 ± 12.0), Min-Max = 21-65		
Overall pesticide protective behaviors (points)		
Low (mean 1.00-2.33)	30	7.5
Moderate (mean 2.34-3.66)	230	57.6
High (mean 3.67-5.00)	139	34.8
(mean ± SD = 98.1 ± 229), Min-Max = 53-150		

Note. Data are expressed as mean ± standard deviation or n (%). SD = Standard deviation

Association between health literacy and pesticide protective behaviors

A positive and significant association was found between overall HL and PPB ($r_s = 0.656$, $p < 0.001$). Further analysis of specific HL dimensions revealed that access to information and services, communication, critical media literacy, and decision-making exhibited moderate positive correlations with PPB ($p < 0.001$).

In contrast, cognitive skills and self-management demonstrated weak positive correlations with PPB ($p < 0.001$).

Factors associated with pesticide protective behaviors among cassava farmers

Factors associated with PPB were analyzed using MLR as shown in **Table 4.** Cutoff points and reference categories for all independent variables were defined based on theoretical rationale, distribution of responses, and relevance to public health outcomes. All variables were assessed for multicollinearity before inclusion in the model and met the required assumptions for logistic regression. The study revealed that cassava farmers with high HL were 4.98 times more likely to have high PPB than those with lower HL (AOR = 4.98, 95% CI = 2.96–8.37, $p < 0.001$). Farmers aged 20–59 years had 1.78 times greater odds of high PPB compared to those aged 60 and above (AOR = 1.78, 95% CI = 1.06–3.00, p = 0.031). Additionally, those with secondary education or higher were 1.73 times more likely to report high PPB than those with only primary education (AOR = 1.73, 95% CI = 1.05–2.85, p = 0.033).

Cassava farmers earning more than 5,000 Thai baht (153 USD) per month were 1.96 times more likely to exhibit high levels of PPB compared to those earning less (AOR = 1.96, 95% CI = 1.13–3.38, p = 0.016). Those who had experienced allergic reactions from pesticide use were 3.32 times more likely to report high PPB than those without such reactions (AOR = 3.32, 95% CI = 1.90–5.80, $p < 0.001$). Additionally, farmers with 1–5 years of pesticide use were 1.89 times more likely to have high PPB than those with over 6 years of use (AOR = 1.89, 95% CI = 1.12–4.01, p = 0.030).

Table 4. Factors associated with pesticide protective behaviors of cassava farmers (n = 399)

Variables	BLR			MLR		
	COR	**95% CI**	***p*-value**	**AOR**	**95% CI**	***p*-value**
Sex						
Male	1.00			1.00		
Female	1.11	0.67–1.84	0.675	1.05	0.57–1.96	0.865
Age (years)						
20–59	2.14	1.40–3.29	< 0.001	1.78	1.06–3.00	0.031
60 or above	1.00			1.00		
Marital status						
Married	1.16	0.72–1.86	0.541	1.35	0.76–2.40	0.314
Single/Separated/Divorced	1.00			1.00		
Education level						
Primary school	1.00			1.00		
Secondary school or higher	1.76	1.16–2.67	0.008	1.73	1.05–2.85	0.033
Monthly income						
0–5,000 Thai baht (0–153 USD)	1.00			1.00		
> 5,000 Thai baht (> 153 USD)	1.92	1.20–3.01	0.006	1.96	1.13–3.38	0.016
Health problems						
No	1.00			1.00		
Yes	1.39	0.92–2.11	0.121	1.24	0.75–2.06	0.405
History of pesticide-related illness						
No	1.00			1.00		
Yes	1.08	0.71–1.65	0.716	1.48	0.83–2.63	0.176

Table 4. Factors associated with pesticide protective behaviors of cassava farmers (n = 399) (Cont.)

Variables	BLR			MLR		
	COR	95% CI	*p*-value	AOR	95% CI	*p*-value
Access to blood chemical testing						
No	1.00			1.00		
Yes	1.10	0.72-1.71	0.653	1.61	0.90-2.88	0.111
Reason for pesticide use						
Hired to spray pesticides	1.00			1.00		
Personally spray pesticides	1.02	0.63-1.67	0.921	1.56	0.84-2.89	0.158
Training in pesticide application						
No	1.00			1.00		
Yes	1.11	0.73-1.68	0.618	1.36	0.78-2.35	0.277
Duration of pesticide use (years)						
1-5	1.96	1.15-3.33	0.013	1.89	1.12-4.01	0.030
6 or more	1.00			1.00		
Frequency of spraying per month (times)						
1-2	1.68	1.09-2.58	0.018	1.19	0.67-2.13	0.545
> 2	1.00			1.00		
Duration per spraying session (hours)						
1-2	1.56	1.03-2.36	0.037	1.13	0.66-1.94	0.647
> 2	1.00			1.00		
Allergic reactions from pesticides						
Yes	2.15	1.34-3.42	0.001	3.32	1.90-5.80	< 0.001
No	1.00			1.00		
Overall health literacy						
Low/ Moderate	1.00			1.00		
High	4.17	2.68-6.51	< 0.001	4.98	2.96-8.37	< 0.001

Note. 1.00 = Reference group; COR = crude odds ratio; AOR = adjusted odds ratio; CI = confidence interval; BLR = binary logistic regression; MLR = multiple logistic regression

Discussion

This study revealed notable gaps in HL and PPB of cassava agriculturists. Only 48.1% had moderate HL, indicating limited understanding of pesticide risks and safe practices. Contributing factors include low educational levels, limited access to health information, inconsistent enforcement of policy, and cultural beliefs about pesticide use.[27] Similarly, 57.6% demonstrated moderate PPB, possibly due to discomfort with PPE, financial limitations, and weak enforcement of safety measures.[28] These findings align with previous studies reporting moderate HL and PPB levels among the majority of participants.[9,12]

HL was significantly associated with PPB among cassava farmers. Previous studies consistently demonstrate a positive relationship between HL and PPB among agricultural workers.[8] Research conducted in multiple regions of Thailand has shown that higher HL is significantly associated with improved adoption of safety practices when handling pesticides.[9,10,20] Cassava farmers with higher HL are more inclined to recognize pesticide risks and adopt protective behaviors, such as using PPE and following safety guidelines.[29] However, many farmers in this study demonstrated low cognitive HL, limiting their ability to understand pesticide labels, identify symptoms, and perceive long-term health risks. Contributing factors may include low education, limited access to health information, and cultural barriers.[30,31]

The findings highlight that HL has a significant influence on PPB. Farmers with higher HL are more likely to use PPE, follow safe handling practices, and seek health advice.[32] Notably, low cognitive HL was common, limiting their ability to understand pesticide instructions or recognize poisoning symptoms, often due to low education, limited training, and communication barriers. Moderate levels of information access and communication indicate some engagement with health services, but a limited ability to interpret or discuss health topics effectively. In contrast, many farmers showed strong self-management, critical media literacy, and decision-making skills, likely shaped by personal experience, which helped support PPB despite gaps in other HL areas.[15,20]

Duration of pesticide use was associated with PPB among cassava farmers. Less experienced farmers were more likely to follow safety guidelines and use PPE, possibly due to recent training, heightened awareness, or supervision through formal education programs.[33] In contrast, experienced farmers may develop risk tolerance over time, leading to complacency and reduced protective behaviors. Continuous safety training, particularly for long-term users, is crucial in reinforcing awareness of chronic health risks. This finding aligns with previous studies among farmers, which also reported an association between pesticide use duration and PPB.[34,35]

Age was associated with PPB among cassava farmers. Younger and middle-aged farmers may be more physically capable, better informed, and more adaptable to safety practices, leading to more consistent PPE use.[36] To address age-related disparities, safety education should be tailored to all age groups, and PPE should be designed for comfort and usability. Community-based support, where younger farmers assist older ones, may also enhance adherence to safety protocols. These findings align with earlier studies that have linked age to PPB among farmers.[27,37]

Allergic reactions from pesticide use were associated with PPB among cassava farmers. Those who did not consistently use PPE—such as gloves, masks, or protective clothing—were more prone to symptoms like skin irritation and respiratory issues.[38] Experiencing such effects may increase risk awareness and motivate safer behaviors. Enhancing safety knowledge and PPE use can reduce allergic reactions and improve farmers' health. These findings align with previous studies linking allergic reactions to increased protective behaviors.[31,38]

Monthly income was associated with PPB among cassava farmers. Those with higher incomes were more likely to purchase quality PPE, reducing pesticide exposure, while lower-income farmers faced financial barriers, leading to inadequate PPE use.[39] Government and agricultural organizations should consider financial support or subsidies for PPE and safer pesticides. These findings align with earlier studies that have shown income influences PPB among farmers.[27,3]

Education level was associated with PPB among cassava farmers. Farmers with higher education levels demonstrated greater awareness and consistent use of PPE. In contrast, those with less education had limited knowledge of pesticide risks and were less likely to adopt protective practices, increasing their vulnerability to health issues.[40] These findings align with previous studies linking education level to PPB among farmers.[27,37]

Limitations

This research faced various limitations. First, the cross-sectional design restricted the capacity to determine causal links between HL and PPB; longitudinal studies are needed to explore causality over time. Second, the study was conducted in one province in the East of Thailand, which may restrict generalizability to other regions with different cultural, economic, or agricultural conditions. Third, the absence of biological measures, such as cholinesterase levels, limits objective assessment of pesticide exposure. Finally, using self-reported data may lead to recall bias and the overestimation of protective behaviors due to social desirability.

Conclusions and Implications for Nursing Practice

This study highlights a significant relationship between HL and PPB among cassava farmers, with a notably low level of cognitive HL observed. Farmers with higher HL were more likely to adopt appropriate protective measures when handling pesticides. These findings underscore the pivotal role of HL in fostering safe practices and mitigating health risks associated with pesticide exposure. These findings can be applied as follows: 1) nurses and healthcare providers should develop targeted health education programs aimed at improving HL among cassava farmers; 2) regular health screenings, including cholinesterase level testing, should be implemented to monitor pesticide exposure among farmers; and 3) policies and regulations are needed to improve access to affordable PPE, enforce safety standards for pesticide use, and incorporate HL training tailored to farmers' needs.

Future studies could use a longitudinal design to explore the causal relationship between HL and PPB over time. Additionally, future research should develop and test educational or training programs tailored to improve HL among cassava farmers. Additionally, future studies should employ qualitative approaches, such as interviews or focus groups, to gain deeper insights into farmers' perceptions, attitudes, and obstacles related to HL and PPB. Lastly, future studies should include cholinesterase levels in the blood as a biomarker to measure pesticide exposure among cassava farmers. This biological indicator can provide objective evidence of pesticide absorption and potential health risks.

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ความรอบรู้ด้านสุขภาพและปัจจัยที่เกี่ยวข้องซึ่งมีอิทธิพลต่อพฤติกรรมการป้องกันสารกำจัดศัตรูพืชของเกษตรกรปลูกมันสำปะหลังในจังหวัดหนึ่งทางภาคตะวันออกของประเทศไทย: การศึกษาแบบภาคตัดขวาง

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บทคัดย่อ: การสัมผัสสารกำจัดศัตรูพืชถือเป็นอันตรายจากการประกอบอาชีพที่สำคัญในกลุ่มเกษตรกรผู้ปลูกมันสำปะหลัง ซึ่งก่อให้เกิดปัญหาต่อสุขภาพและสิ่งแวดล้อมหลายประการ ความรอบรู้ด้านสุขภาพมีบทบาทสำคัญในการช่วยให้เกษตรกรสามารถเข้าใจและนำไปสู่การปฏิบัติพฤติกรรมป้องกันอันตรายจากสารกำจัดศัตรูพืชได้อย่างมีประสิทธิภาพ การศึกษาภาคตัดขวางครั้งนี้มีวัตถุประสงค์เพื่อศึกษาความรอบรู้ด้านสุขภาพและปัจจัยที่มีอิทธิพลต่อพฤติกรรมการป้องกันสารกำจัดศัตรูพืชของเกษตรกรปลูกมันสำปะหลัง กลุ่มตัวอย่าง คือ เกษตรกรปลูกมันสำปะหลังที่ขึ้นทะเบียนในจังหวัดหนึ่งทางภาคตะวันออกของประเทศไทย จำนวน 399 คน มีอายุระหว่าง 20–65 ปี และมีประสบการณ์การใช้สารเคมีในการปลูกมันสำปะหลังไม่น้อยกว่า 1 ปี การเก็บรวบรวมข้อมูลดำเนินการระหว่างเดือนธันวาคม 2567 ถึง มกราคม 2568 โดยใช้แบบสอบถามแบบมีโครงสร้าง ประกอบด้วย แบบสอบถามปัจจัยด้านบุคคลและสุขภาพ ปัจจัยการใช้สารเคมี ความรอบรู้ด้านสุขภาพเกี่ยวกับการใช้สารกำจัดศัตรูพืช และพฤติกรรมการป้องกันสารกำจัดศัตรูพืช วิเคราะห์ข้อมูลด้วยสถิติเชิงพรรณนาและการวิเคราะห์ถดถอยโลจิสติกพหุคูณ

ผลการศึกษา พบว่า เกษตรกรปลูกมันสำปะหลังส่วนใหญ่มีระดับสุขภาพรอบรู้โดยรวมในระดับปานกลาง (ร้อยละ 48.1) และมีพฤติกรรมป้องกันอันตรายจากสารกำจัดศัตรูพืชในระดับปานกลาง (ร้อยละ 57.6) ความสัมพันธ์ระหว่างความรอบรู้ด้านสุขภาพกับพฤติกรรมป้องกันอันตรายจากสารกำจัดศัตรูพืชมีความสัมพันธ์ในเชิงบวกอย่างมีนัยสำคัญทางสถิติ ปัจจัยที่มีความสัมพันธ์กับพฤติกรรมป้องกันอันตรายจากสารกำจัดศัตรูพืชอย่างมีนัยสำคัญ ได้แก่ ความรอบรู้ด้านสุขภาพ อายุ ระดับการศึกษา รายได้ต่อเดือน การเกิดอาการแพ้จากการใช้สารกำจัดศัตรูพืช และระยะเวลาการใช้สารกำจัดศัตรูพืช โดยพบว่าความรอบรู้ด้านสุขภาพเป็นปัจจัยที่มีอิทธิพลสูงสุด การศึกษานี้ชี้ให้เห็นว่า ความรอบรู้ด้านสุขภาพเป็นปัจจัยสำคัญในการส่งเสริมพฤติกรรมการป้องกันสารกำจัดศัตรูพืช ดังนั้น การพยาบาลควรเน้นการจัดกิจกรรมให้ความรู้ที่ส่งเสริมความรอบรู้ด้านสุขภาพ เพื่อให้เกษตรกรมีพฤติกรรมการใช้สารกำจัดศัตรูพืชอย่างปลอดภัยมากขึ้น รวมทั้งชี้ให้เห็นถึงความจำเป็นของนโยบายสาธารณสุขที่ส่งเสริมความรอบรู้ด้านสุขภาพในโปรแกรมความปลอดภัยด้านเกษตรกรรม เพื่อคุ้มครองสุขภาพของประชาชนในชุมชนเกษตรกรรม

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คำสำคัญ : แรงงานภาคเกษตร มันสำปะหลัง เกษตรกร ความรอบรู้ด้านสุขภาพ สารกำจัดศัตรูพืชพฤติกรรมการป้องกัน

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