



Effects of Occupational Health Prevention Program among Thai Farmers

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Abstract

The problem of inappropriate chlorpyrifos usage is an important concern for workers who have direct exposure. The purpose of the study was to evaluate the effectiveness of occupational health prevention program among Thai farmers, using a quasi-experimental design with the two-groups: pre-test-post-test. The samples consisted of 70 farmers who had mixed or sprayed CPF and used CPF spray for more than a year and had unsafe blood cholinesterase enzyme level. 35 subjects in each group were equally assigned by random assignment to an experimental group and a control group, and both groups had no difference in the characteristics. Those in the experimental group received the occupational health prevention program at week 1, but those in the control group received the usual care. Outcomes were measured before intervention (baseline), and at 1 and 4 weeks after intervention, and then data were analyzed with descriptive and using repeated measures of ANOVA testing. The findings reveal that participants in the intervention group had improved self- protective behavior and blood cholinesterase enzymes, and had lower symptoms. They have differed from the control group with statistical significance ($p < 0.001$). Thus, this program should be considered for implementation to improve the safe use of Chlorpyrifos.

Introduction

Chlorpyrifos (CPF) is a widely used organophosphate insecticide. In Thailand, CPF is regulated and resisted by the network in support of banning dangerous chemicals (Biodiversity sustainable Agriculture Food sovereignty action Thailand, 2018). Thai workers have been affected by exposure to CPF, about a 12.25 per hundred thousand people while reported illness is increasing every year (Bureau of Occupational and Environmental Diseases,

2018; Yuyen et al., 2013). CPF causes both chronic and acute illness. CPF chronic toxicity affects the dermatological system; dermatitis and blisters are presented, as well as affecting the respiratory system with webbing in the lungs (Corsini et al., 2013). Ismail et al. (2012) reported on chronic neurological symptoms such as alertness of consciousness, adverse cognitive problems i.e., memory loss, poor attention and low concentration, and also the emotional and psychological disorders; anxiety, stress, irritability and depression (Ismail et al., 2012).

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In cases of acute condition caused by acetylcholinesterase enzymes being inhibited (Wafa et al., 2013), and that refers to acetylcholine overdose. An acute condition represents neuro-muscular symptoms of acute toxicity in farm workers. The previous studies reported that a prevalence of acute CPF poisoning among workers in developing countries was very high (Jensen et al., 2011; Karunamoorthi et al., 2012). The prevalence of CPF toxicity reported acute CPF toxicity symptoms on measuring self-reported when determining the prevalence. Nevertheless, acute toxicity symptoms are rather unspecific, they can have multifarious initiation, for example dehydration, heat stroke, or others symptoms and diseases.

The measuring of cholinesterase enzyme in blood, in addition to sudden CPF toxicity symptoms, is recommended when evaluating acute CPF toxicities. Plasma cholinesterase (PchE) procedure is a valid biomarker of acute CPF exposure and toxicities (Kapka-Skrzypczak et al., 2011), the results of some studies have assessed cholinesterase correlated to worker's CPF toxicities (Wafa et al., 2013; Oliveira et al., 2012), and those studies have mainly examined workers chronic CPF toxicities. PchE can be easily detected using test kits that are inexpensive and easy to use for testing. The Ministry of Public Health Thailand found the farmer's Health Clinic where they promote worker's health especially for people who work in farming areas.

A majority of farmers usually lack caution and do not engage in self-protective behaviors when using CPF. They are directly exposed which can lead to illness. Blood cholinesterase enzyme levels have shown that exposed farmers are at an obvious risk due to this fact (Bureau of Occupational and Environmental Diseases, 2018). However, in previous study, Sanprakhon and colleague claimed that nurse practitioner and health care providers who work in farmer's Health Clinics are able conduct the conceptual framework of health beliefs model for behavior modification to improve self-protective behaviors when using CPF by promoting perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. Becker and others revealed that a person, who needs to modify behaviors, must perceive susceptibility and perceive severity to disease in order to perceive threats from diseases by selecting ways considered as the best solution for avoiding the threats, and one must compare benefits from proper practice and negative effects by perceiving a barrier as a guide to

good practice that will lead to good personal behaviors (Becker, 1990). The findings of a previous study have recommended that the application of the health belief model is able to contribute to the prevention of negative behaviors from using insecticides (Somboon et al., 2010).

Therefore, this study implemented a health belief model to conduct the health promotion program among farmers, and created activities that combined a Chlorpyrifos Safety Checklist that was performed to develop perceived susceptibility and perceived severity of health impacts. The Chlorpyrifos Safety Checklist is a self-report that can remind and monitor health effects from using CPF such as the symptoms and plasma cholinesterase. Thus, the purpose of the study was to evaluate the effectiveness of occupational health prevention program among Thai farmers.

Materials and methods

This study used a quasi-experimental research design with two-groups; pre-test/post-test.

1. Scope of study

A quasi-experimental study was conducted in Suphanburi Province, Thailand: Nong Bua Village in U-thong District using simple random sampling as the control group and Ladmakham Village in Song Phi Nong using simple random sampling as the intervention group. The distance between the control and experimental group areas is around 40 kilometers. Both villages have similar time periods for growing rice and using chlorpyrifos. Evaluation: first time was before intervention, second time was after intervention at 2 weeks and follow-up at 4 weeks for both intervention and control groups. The cultivation cycle period in growth is around 100 - 120 days, Therefore 4 weeks of follow-up period in both areas was appropriate for examination of the effectiveness of the intervention at the same time as CPF application.

2. Participants

The sample population comprised of farmers in Suphanburi. The subjects included 70 farmers by sample random sampling with the following qualifications: Thai farmers who had mixed or sprayed CPF and used CPF spray for more than a year. The inclusion criteria of participants were aged 18 - 59 years old, unsafe blood cholinesterase enzyme levels, no diabetes or medication that could disturb the analysis of cholinesterase enzymes, and the ability to read and communicate in Thai language.

3. Sample size and randomization

The sample size used power analysis by G * Power 3.0.10 program. One-tailed test measures the sample size of the two independent groups. The sample size of the two sample independent groups is used to determine the size of the sample. The effect size was identified from a previous study (Somboon et al., 2010) that showed the mean of the experimental group was 39.93 ± 5.30 and control group was 32.18 ± 5.90 . The effect was too large size, and a sample size of less than 30 persons in each group were not sufficient to indicate a significant difference at the statistical significance level of 0.05. The magnitude of the influence was 0.80 in G* Power 3.0.10. The confidence level was 0.05. The power of test was 95 (Cohen, 1997). The sample size was 35 persons per group.

The random sampling was used in 10 districts in Suphanburi area. The first random sampling was in the Song Phi Nong district, and the second random sampling was in U-thong. Researchers conducted a simple random sampling of 14 sub-district in Song Phi Nong and 13 in U-thong (Banglane sub-district and Chorakae samphan sub-district, respectively). Ladmakham village and Nong Bua village were simple randomized in experimental and control group, respectively). A subject per household was simple randomized, the selection technique of the samples in the two areas are similar, and were considered in criteria of gender, age and education, using the following criteria: recent usage of chlorpyrifos, frequency of using chlorpyrifos. The samples were divided into two groups: 35 samples in the experimental group and 35 samples in the control group; as shown in Fig. 1

The questionnaires used in the study were modified and adjusted from literature review to be appropriate for this particular study (Markmee et al., 2013). Both of the questionnaires passed the content check from the qualified 3 persons, and then the researchers adjusted based on recommendations. Calculations were based on the Content Validity Index (CVI). The reactive paper for cholinesterase enzyme was accepted in both the CVI and Cronbach'Alpha Coefficient, but which was used a validation for testing serum cholinesterase levels. The measurement for collecting data includes:

1. Self-protective behaviors from using CPF questionnaire was developed by literature review (Markmee et al., 2013; Sanprakhon et al., 2017), content of validity index (CVI) is 0.86., and reliability was tested by Cronbach'Alpha Coefficient at 0.94. The questionnaire consists of 26 questions, and all questions

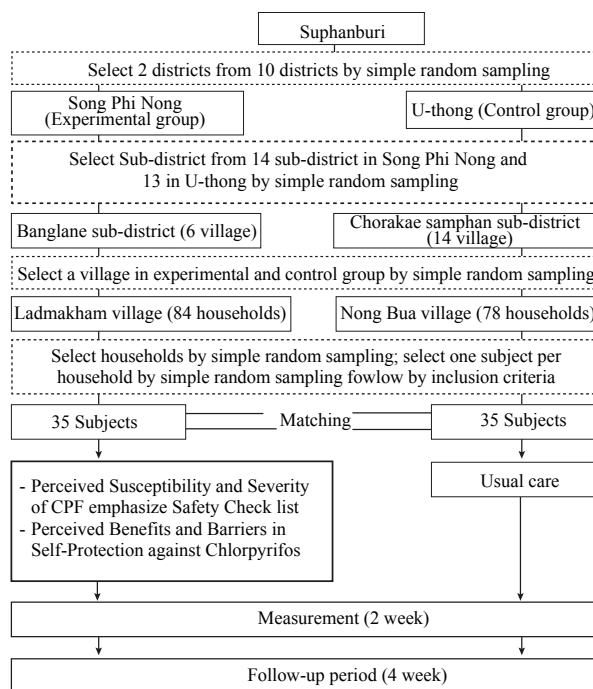


Fig. 1 Diagram of sampling technique and protocol

involved the responders practices in term of “did” or “did not”.

2. Symptom from using chlorpyrifos questionnaire 31 items. The question is closed, divided into two levels, Have and None. The questionnaire calculated at CVI (1.0) and reliability was tested by Cronbach'Alpha Coefficient at 0.91.

3. Reactive paper for cholinesterase enzyme in blood from Department of Health, Ministry of Public Health was used as a validation and was shown 77% in sensitivity, 90% specificity and 85% positive predictive values for testing serum cholinesterase level.

4. Outcomes

A Likert scale for the reliability symptoms related to using CPF used the formula of Cronbach's Alpha. Outcome measurements, dependent variables consist of 3 parts:

4.1 Self-protective behaviors consisted of three parts: 1) pre-exposed to CPF, 2) During direct exposure; mixed and applying CPF and 3) after using CPF period.

4.2 Plasma cholinesterase enzymes was pre-specified primary outcome; Biological Indicators of exposure to CPF using Biggs's Method (Bigg et al., 1958). This method has generally been used to measure anti-

cholinesterase over a long time period by the Ministry of Public Health. Blood samples were taken from farmers by using capillary tubes after exposure to CPF. The capillary tubes were placed at room temperature until separation of serum and red blood cells. Reactive paper was then placed on slides with a clamp. A drop of serum was placed on reactive paper and left for seven minutes before reading the results by comparing differences in color. They were measured in four categories including normal, safe, risky and unsafe. The test results interpretation was as follows: 1) Normal (> 100 units per milliliter) when reactive paper did not change color; 2) Safe (87.5 - 99.9 units per milliliter) when reactive paper changed color to yellow; 3) Risky (75 - 87.4 units per milliliter) when reactive paper changed color to green and 4) Unsafe (< 75 units per milliliter) when reactive paper changed color to green-blue. When data was collected and before intervention Chlorpyrifos safety checklist and occupational health prevention program created health belief model. The health belief model consisted of perceived risk, severity of CPF using, perceived benefits and barriers for self-protection. Chlorpyrifos safety checklist was used to emphasize and remind farmers to monitor health effects from using CPF which consists of symptom and plasma cholinesterase level. The collaboration in monitoring will increase perceived susceptibility, severity of CPF, perceived benefits and barriers for self-protection. When, activities were conducted for a period of four weeks in May 2017, CPF was most frequently used.

4.3 Symptoms related to using CPF was secondary outcome measure; the questionnaire was created by literature review (Markmee et al., 2013). There were 31 symptoms specified in the questionnaire. These were categorized into 5 groups by organ system as follows: 1) Neurology System (17 symptoms): insomnia, malaise, dizziness, headache, numbness, palpitation, sweating, excessive salivation, twitching eyelids, blurred vision, muscle weakness, muscle cramps, tremor, staggering gait, seizure, coma, unconsciousness 2) Respiratory system (6 symptoms): cough, burning nose, sore throat, dry throat, wheezing, runny nose, tightness or burning chest 3) Dermatology System (3 symptoms): itchy/dry skin, rash, irritation 4) Ophthalmology System (2 symptoms): burning/stinging/itchy eyes, and excessive tearing and 4) Gastrointestinal (3 symptoms): nausea or vomiting, abdominal pain, and diarrhea.

5. Collection of data

Both the experimental group and control group data were collected in pre-intervention at 1 week by self-protective behaviors from using CPF questionnaire, Symptoms related to using CPF questionnaire, and serum cholinesterase levels. A repeat of data were collected using post-intervention and follow-up period in weeks 2 and 4, respectively.

6. Intervention

The Occupational Health Prevention Program was created by health belief model and literature review from Makmee and colleagues (Makmee et al., 2013) and Sanprakhon and others (Sanprakhon et al., 2017). The intervention was conducted at CVI = 1 and then participants in experimental group received intervention at week 1 after data collection, in contrast the control group was not, in as follows;

6.1 Activities were conducted by perceived susceptibility and severity, whereby the researcher took blood tests to determine blood cholinesterase enzyme levels in the experimental group before the experiment. The researcher then informed the experimental group personally regarding blood cholinesterase enzyme levels in addition to using the chlorpyrifos safety checklist to increase perceived susceptibility and severity from using CPF at each step of rice farming. In addition, the researcher explained the risks related to reduction in blood chlorpyrifos enzyme levels and summarized the chlorpyrifos safety checklist in order to determine the severity of effects on subjects' health. The subjects were then divided into three groups concerning discussion of the topic (Wongwisesskul et al., 2017), "How do you feel about incidences of illness caused by CPF and its effects on your health?" Representatives were sent to present information to every group of subjects for acknowledgement. The researcher then used PowerPoint presentations to explain toxicity, route of exposure and health effects of chlorpyrifos in order to raise awareness among the subjects regarding the severity of CPF.

6.2 Activities for providing perception of benefits and barriers to self-protective behaviors concerning use of CPF, consisted of activities to raise awareness of perception of benefits and barriers to self-protection in using CPF. The researcher used PowerPoint presentations to explain the benefits of self-protection when using CPF and demonstrated methods for using personal protective equipment when applying or mixing CPF. Next, the researcher had the subjects hold group discussions by

dividing the subjects into three groups in order to reflect on the problems and barriers from self-protection in terms of using CPF on the topic, “Reasons and Guidelines for Solving Problems that Prevent Self-protection when Using CPF”.

Activities included the occupational health prevention program, as shown in Table 1

Table 1 Activities of occupational health prevention program

Principles	Activities	Time (hours)
Perceived Susceptibility and Severity of CPF Use	1) Informing the subjects of results from blood cholinesterase enzyme levels tests individually. 2) The Chlorpyrifos Safety Check list for self-report in order to assess risks in each stage of rice farming and 3) hold group discussions on incidence of illnesses caused by CPF. - consisted of education on toxicity, channels of contact and dangers from CPF by using Power Point presentations. - Using the results of the Farmers Safety Checklist to determine the severity of potential effects on farmers' health in the sample group.	2.5
Perceived Benefits and Barriers in Self-Protection against Chlorpyrifos	1) Explanation of benefits from self-protective when required to come into exposure to CPF and benefits from using personal protective equipment by using Power Point presentations. 2) demonstrations of methods for using personal protective equipment to help the subjects perceive the benefits of self-protective against CPF and 3) group discussions on “Reasons and Guidelines for Solving Problems that Prevent Self-Protection When Using CPF”	1.5

7. Ethics statement

This study was approved by the 2/2560 Ethical Review Committee for Research in Human Subjects, Burapha University, Thailand. All participants were informed of the study objectives, and were provided detailed explanations of every step in this study. This study allowed the subjects to make independent decisions to participate without coercion, and they had the right to withdraw from the study at any time, without any adverse consequences for them.

8. Statistical Analysis

The SPSS computer program was used to set significance at .05 by using descriptive statistics; frequency, percentage, mean and standard deviation were used to describe participants' characteristics. Differences between baseline characteristics in the intervention and control groups were assessed by

independent t-test and chi-square test. For evaluating the effectiveness of the program of differences between the experimental and the control group, the effect of the intervention on self-protective behaviors scores, serum cholinesterase level, and symptoms at three time points: Pre-experiment, after intervention and four weeks after intervention (follow-up) which were determined with repeated measurement using ANOVA.

Results and discussion

1. Demographic Data of Thai farmers

There were 70 participants originally enrolled in this study. The mean age was 44 years, and most of these (62.9%) had had graduated from primary school. Mean of the duration of using CPF was at least 12 years (27.15%). One in three of all subjects (35.75%) used CPF nine times a month while fifty-four percent of the farmers took three hours from mixing to applying CPF. Most of the subjects followed directions when they mixed the CPF (64.3%), as shown in Table 2

Table 2 Demographic data for Thai farmers

Characteristic	Experimental group	Control group	t	χ^2	p-value
Age					
Mean±SD	44.8±3.3	44.3±2.9	.56		0.53
Education				1.0	0.79
Primary School	22(31.4)	22(59.5)			
Secondary School	11(15.7)	12(32.4)			
Bachelor's Degree	1(1.4)	1(2.7)			
Higher than Bachelor's Degree	1(1.4)	2(5.4)			
The duration of using CPF was at least (years)					
Mean±SD	12.3±5.9	12.4±5.7	-0.04		0.97
Frequency of using from the CPF (/Months)					
Mean±SD	8.6±9.5	9.0±8.5	-0.20		0.84
Duration of Applying to CPF (Hours)					
Mean±SD	3.3±1.3	3.2±1.3	0.27		0.79

2. Self-protective behaviors from using chlorpyrifos

Self-protective behaviors from using chlorpyrifos with a questionnaire showed that the experimental group had increased and higher than pre-intervention. Comparing between experimental and control groups after intervention and a follow-up showed that mean self-protective behaviors rising in the experimental group more than both periods of the control group. The difference was statistically significant ($F = 4122.7$, $df = 1$, $p < 0.05$), as shown in Table 3

Table 3 Comparison of self-protective behaviors from using CPF means between experimental and control groups

Source of Variables	SS	df	MS	F ^a	Observed Power ^a
Self-protective behaviors from using CPF means					
During Subject Treatment	531.22	1	531.22	4122.7*	1.00
Error	8.76	68	.13		

Remark: * $p < .05$, SS = Sum of Aquare, df = degree of freedom, MS = Mean Square

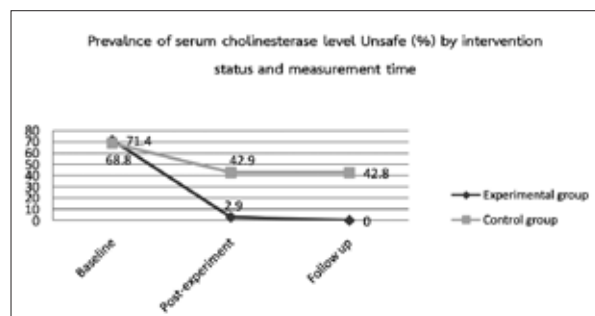
a = Greenhouse's Geisser correction was used to reduce type error

3. Biological Indicators of Exposure to CPF by Using Blood Cholinesterase Enzymes

According to a preliminary survey, the experimental and control groups were risky and unsafe based on the blood cholinesterase enzyme levels, however, the experimental group was found to have the increased blood cholinesterase enzyme at normal and safe levels in both the post-experiment and follow-up period. The difference of increased blood cholinesterase enzyme between the experimental and control groups at both of the post-experiment and follow-up period was statistically significant ($p < 0.05$), as shown in Table 4 and Fig. 2.

Table 4 Comparison of Differences in Cholinesterase among the Experimental Group and Control Group at Pre-test, Post-test and Follow-up

Cholinesterase Levels	Pretest				Posttest				Follow-up			
	Experimental Group		Control Group		Experimental Group		Control Group		Experimental Group		Control Group	
	No. (Subj)	%	No. (Subj)	%	No. (Subj)	%	No. (Subj)	%	No. (Subj)	%	No. (Subj)	%
Normal (>80 u/ml)	0	0	0	0	4	11.4	0	0	21	60	0	0
Safe (70-80 u/ml)	0	0	0	0	13	37.1	2	5.7	12	34.3	3	8.57
Risky (60-70 u/ml)	10	28.6	11	31.4	17	48.6	18	51.4	2	5.7	17	48.57
Unsafe (<60 u/ml)	25	71.4	24	68.6	1	2.9	15	42.9	0	0	15	42.86
Total	35	100	35	100	35	100	35	100	35	100	35	100

**Fig. 2** Comparison of differences in cholinesterase levels unsafe (%) between the experimental and Control Groups by intervention status and measurement time

4. Symptoms of the Neurological, Respiratory, Dermatological, Ophthalmological and Gastrointestinal Systems

According to a preliminary survey, the experimental and control groups were not different in the symptoms of the neurological, respiratory, dermatological, ophthalmological and gastrointestinal systems, however, the experimental group decreased those symptoms in both the post-experiment and the follow-up period. Differences between experimental group and control group; effects of occupational health prevention program among various symptoms, the neurological, respiratory, dermatological, ophthalmological and gastrointestinal systems, showed a decreased statistically significant ($p < 0.05$) in both the pre-post experiment and the follow-up. Which also found an interaction between occupational health prevention program with time measurement affects the neurological, respiratory, dermatological, ophthalmological and gastrointestinal systems ($p < 0.05$), as shown in Table 5.

Table 5 Comparison of symptoms between the experimental and control group at pre-experiment, post-experimental and follow-up periods

Source of Variables*	SS	df	MS	F	P
Symptoms	942.976	1	942.976	3675.136	<.001**
Neurology System	6.876	1	6.876	17.866	<.001**
Respiratory System	6.171	1	6.171	12.877	<.001**
Dermatology System	4.576	1	4.576	8.947	.004**
Ophthalmology System	12.876	1	12.876	53.764	<.001**
Gastrointestinal system	4.286	1	4.286	9.993	.002**

Remark: *Greenhouse's Geisser, ** $P < 0.05$

The findings of this study shows that occupational health prevention program was effective in improving the outcome that related to participant's health; self-protective behaviors from using CPF score and blood cholinesterase enzyme levels both post-experiment and follow up at week 2 and week 4 after the intervention. In contrast, the occupational health prevention program reduced exposure to chlorpyrifos among farmers showed it was effective in improving and decreasing symptoms. Because of the aforementioned program, that implemented the health belief model on participants in the following four areas: 1) Perceived susceptibility; 2) Perceived severity; 3) Perceived benefits and 4) Perceived barriers (Becker, 1990).

The hypothesis was focused on providing perceived susceptibility and severity from activities, as well as informing blood cholinesterase enzymes levels individually and using the chlorpyrifos safety checklist

to increase perception of potential susceptibility from CPF use in each step of rice farming. Moreover, the findings were used to determine severity levels with potential for impact on farmer's health, thereby causing the subjects to have awareness of potential risks to their health, perceived susceptibility and severity through group discussions in order to provide perceived health threats from CPF use. This enabled the subjects to avoid risky behaviors and modify self-protective behaviors. The subjects also perceived benefits and barriers that related to self-protection when exposed to CPF by the researcher's explaining the benefits of personal protective equipment for reducing exposure to CPF, causing the subject to understand and perceive the benefits from all activities and barriers. Therefore, the participants were able to select the behavior needed to create benefit and adopt correct and suitable self-protective behaviors. This was evident during the post experiment and follow-up period when participants had better self-protective behaviors. Therefore, the effects of the occupational health prevention program reduced exposure to CPF among farmers such as blood cholinesterase enzyme levels rose and abnormal symptoms were reduced. The findings concurred with a study conducted by Markmee and colleagues, who studied the effects of a behavior modification program to protect against pesticides and reduce neurological and muscle symptoms among farmers in Sukhothai, Thailand, and reported higher self-protective subject behavior scores with statistical significance after one month ($p<0.001$). The intervention program had effectively reduced prevalence of serum cholinesterase unsafe level by 47.3 percent-points ($p<0.001$) at one month and 41.8 percent-points ($p<0.001$) at four months after intervention, prevalence of neuromuscular symptom by 34.1 percent-points ($p<0.001$) at one month and 30.8 percent-points ($p<0.001$) at four months after intervention, prevalence of respiratory symptom by 46.2 percent-points ($p<0.001$) at one month and 34.1 percent-points ($p<0.001$) at four months after intervention, prevalence of digestive symptom by 14.3 percent-points ($p<0.004$) at one month and 34.1 percent-points ($p<0.006$) at four months after intervention, prevalence of eyes symptom by 56.0 percent-points ($p<0.001$) at one month and 47.3 percent-points ($p<0.001$) at four months after intervention, and prevalence of skin symptom by 16.5 percent-points ($p<0.001$) at one month and 29.7 percent-points ($p<0.001$) at four months after intervention. (Markmee et al., 2013). The findings by Sanprakhon

et al. (2017) found that the program conducted by farmers in the experimental group had better different mean self-protective behavior scores from pre-experiment and at 2 months post-experiment and up with statistical significance ($p<0.001$) (Sanprakhon, 2017). In addition, mean self-protective behavior scores improved, causing blood cholinesterase enzyme levels in farmers to escalate by Somboon and others, who reported that workers with proper self-protective behaviors had normal blood cholinesterase enzyme levels (Somboon et al., 2010). Abnormal symptoms were lower in the post-experiment and follow-up periods ($P<0.05$).

Conclusion

The subjects reduced their exposure to chlorpyrifos, causing blood cholinesterase enzyme levels to increase and abnormal symptoms in various systems to be reduced. Thus, this intervention program should be implemented in other rice farm areas. The success of this program depends on the health belief.

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