

The effects of a pesticide application program on improving knowledge and attitude related to pesticide use: A quasi-experimental study among rice farmers in Thailand

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ABSTRACT

In the agricultural sector in Thailand, the heavy use of pesticides can have a negative impact on the health of elderly farmers. This study aimed to evaluate the effects of an application program on improving knowledge and attitude related to pesticide use among rice farmers in Ongkharak, Nakhon Nayok Province, Thailand. In this quasi-experimental study, two communities in different sub-districts were randomly selected for the intervention and the control groups. The inclusion criteria were 45–59-year-old rice farmers involved in the entire process of growing rice that was related to pesticide use. Multistage random sampling was employed by selecting one rice farmer from each rice farmer's household. Of these, 37 farmers each were assigned to the intervention group and the control group, respectively. The data were collected at the baseline and four months after the intervention. A structured face-to-face interview questionnaire was administered to the participants. The pesticide application program was based on observation learning under the social cognitive theory and consisted of three elements over a three-month period: (1) knowledge and training, (2) risk communication, and (3) health surveillance.

The intervention effect was assessed by measuring 1) the participants' knowledge on the safe use of pesticides and 2) their attitude related to pesticide use. The general linear model repeated-measure analysis of variance (ANOVA) was used to generate figures by group and time. The pesticide application program had effectively improved the intervention group members' knowledge on the safe use of pesticides and their attitude related to pesticide use at follow-up compared with the mean score at the baseline. Future studies should focus on the health effects of using pesticides on elderly rice farmers and vulnerable groups, as well as include programs that can sustainably reduce the health risks from their pesticide use.

Key words: pre-elderly farmers, rice farmers, pesticide application program, pesticides

INTRODUCTION

The number of elderly people in Thailand has continuously increased with each passing year, comprising 16.7% of the population in 2019¹. Along with the changes in Thailand's population structure and labor structure, the likelihood of an increased number of working elderly people has also been revealed. Of the total number of elderly people who were able to undertake economically important activities in 2019, 60.3% worked in the agricultural sector². However, this sector's heavy use of pesticides can have a negative impact on the health of elderly people because their bodies are declining. Due to their age, they are more vulnerable to chemical substances, and their health is easily affected in an adverse manner. Although only 3% or less of the total number of people who had been exposed to chemicals were elderly, even negligible exposure proved to have medium and fatal levels of damaging impact on their health³. Thus, elderly people who still engage in agriculture risk illnesses resulting from pesticides⁴. According to the data on patients who were affected by pesticides in 2018, the elderly accounted for 25.1%⁵.

Despite the fact that Thailand is becoming an aging society, most studies on pesticide use among farmers show that the average age of the population is in the pre-elderly group and that pesticides are still not used properly⁶⁻⁹. In the scenario of their being old and their health deteriorating, pesticide exposure could cause severe symptoms. Therefore, preparation should be made to promote the health of pre-elderly farmers so that they have a better understanding and a positive attitude toward the safe use of pesticides, which will influence proper practices for pesticide use. By contrast, if pre-elderly farmers are not encouraged to use them properly, they will be affected by the continued use of pesticides as they become older and may then face serious health effects.

Nakhon Nayok, a province in central Thailand, has a good irrigation system and is able to retain water for agricultural use throughout the year. The majority of the population sustains itself by rice farming. The agricultural land used for rice farming comprises 86.3%¹⁰. Ongkharak is one of the districts with an efficient irrigation system, resulting in three to five crops per year, so most agriculturists there are rice farmers¹¹. In 2017, moreover, Ongkharak had the largest area in the province, with 33% of the paddy fields, and 84% of the plantation area was used to grow rice¹²⁻¹³.

Research on pesticide use in the area discovered that 53.2% of the farmers were 45 years old or above and will be part of the aging population in the near future. In this study, 22.3% of the farmers still had incorrect information concerning some pesticide use; for example, farmers believed that some pesticides, such as paraquat, were not hazardous to their users. Hence, they viewed it as unnecessary to wear a respirator while spraying a pesticide. Furthermore, some farmers still wrongly believed that pesticides can enter the body only through inhalation. In addition, there were still some farmers who had a negative attitude toward the use of personal protective equipment (PPE). In addition, it was found that there were farmers who believed that, in cases of mild allergic reactions to pesticides, the body can recover by itself without medical attention from a doctor. This attitude may cause them to neglect their health care and result in chronic health problems¹⁴.

Moreover, research about pesticide use and its effects on the local farmers' health revealed that farmers who were directly exposed to pesticides were significantly more likely to develop eye symptoms¹⁵. A similar study done in the area revealed that rice-growing farmers there may be at risk of adverse health effects due to dermal exposure to pesticides

from their improper use of PPE¹⁶. These effects on health can stem from a lack of awareness and understanding, as well as negative attitudes toward the safe use of pesticides, potentially leading to inappropriate pesticide practices.

As found in research conducted in the study area, most of the population are farmers and are affected by the improper use of pesticides. This may be due to a lack of knowledge, including having a negative attitude toward the safe use of pesticides. However, if there is no proper knowledge and understanding, farmers in the area may be affected by the long-term health effects of pesticides. Moreover, the strengths of the pesticide intervention program were building knowledge and understanding as well as promoting a positive attitude among farmers through various means. However, weaknesses still exist regarding (1) a lack of local coordinators with health literacy and the ability to be mainstays in the operation of the program and (2) a lack of record-keeping data on the pesticide use of farmers, including a monitoring system that continually monitors the health effects of pesticide use.

For these reasons, we developed a safety program to provide knowledge about pesticide use and modify attitudes in order to promote appropriate pesticide practices. The intervention program was based on observation learning under the social cognitive theory (SCT)¹⁷⁻¹⁹. Additionally, a risk communication process²⁰ and a health surveillance procedure from a previous study²¹ were applied and modified for this study setting. We also sought cooperation with health-promoting hospitals, village health volunteers, and community leaders, who were assigned roles in the program to encourage the people in the community to observe safety standards for pesticide use in the hope that this would further promote health and environmental safety. Our study was carried out in Ongkharak District,

which has the largest number of rice fields in Nakhon Nayok Province. Most of the local people are farmers¹². Our study aimed to evaluate the effects of an application program on improving knowledge and attitude related to pesticide use among rice farmers in Ongkharak. The sample consisted of 45–59-year-old farmers. This age group has been targeted by health measures implemented by the Ministry of Public Health in order to handle the aging population, with its campaign to prepare the pre-aging population for aging²². Our study is expected to be beneficial to the public health administration and other relevant local organizations in planning safety measures for pre-aging and aging populations.

METHODS

Study design and setting

This quasi-experimental study was conducted among rice farmers in Ongkharak District, Nakhon Nayok Province, Thailand. There are 11 subdistricts in the Ongkharak district. Two communities in different subdistricts were randomly selected for the intervention and control groups. The farms were located within a 15-km distance between the subdistricts. In the study area, the irrigation technology in most communities has been updated, and rice cultivation lasts for four months (with rice being harvested three times per year). Both rice farming areas had the same planting season and similar pesticide application. The study was conducted from March to November 2018.

Sample size and sampling technique

The inclusion criteria were 45–59-year-old rice farmers involved in the entire process of growing rice that was related to pesticide use. The number of participants

was calculated with the PS: Power and Sample Size software, version 3.1.6,²³ developed from a previous study²¹. The predicted minimum required sample size comprised 34 participants per group. Approximately, 10% of the participants were added in case of dropouts. Multistage random sampling was employed by selecting one rice farmer from each rice farmer's household. Of these, 37 rice farmers per group completed the study.

Research instrument and data collection

The data were collected at the baseline and four months after the intervention by the team members, who included health officers and researchers from the district. The structured questionnaire was adapted from previous studies^{21,24-25} and divided into four parts: (1) socio-demographic characteristics—gender, age, marital status, education, monthly family income—and smoking habits; (2) work characteristics—years

working in rice farming, work hours per day (interviews about working hours per day in the farming occupation), and farm size; (3) knowledge on the safe use of pesticides; and (4) attitude related to pesticide use. The purpose was to assess the intervention effects by measuring knowledge on the safe use of pesticides, and attitude related to pesticide use among the rice farmers (Figure 1). There were 20 close-ended questions concerning the knowledge on the safe use of pesticides and 20 interview items on the attitude related to pesticide use on a Likert rating scale of 1–5 points (points were given for positive or negative direction questions). The questionnaire was validated with pilot testing for reliability on 30 rice farmers in Potan Subdistrict, Nakhon Nayok Province. KR-20, which was 0.79, assessed the reliability of the knowledge of the safe use of pesticides, and the internal consistency reliability (Cronbach's α) of the attitude related to pesticide use was 0.86.

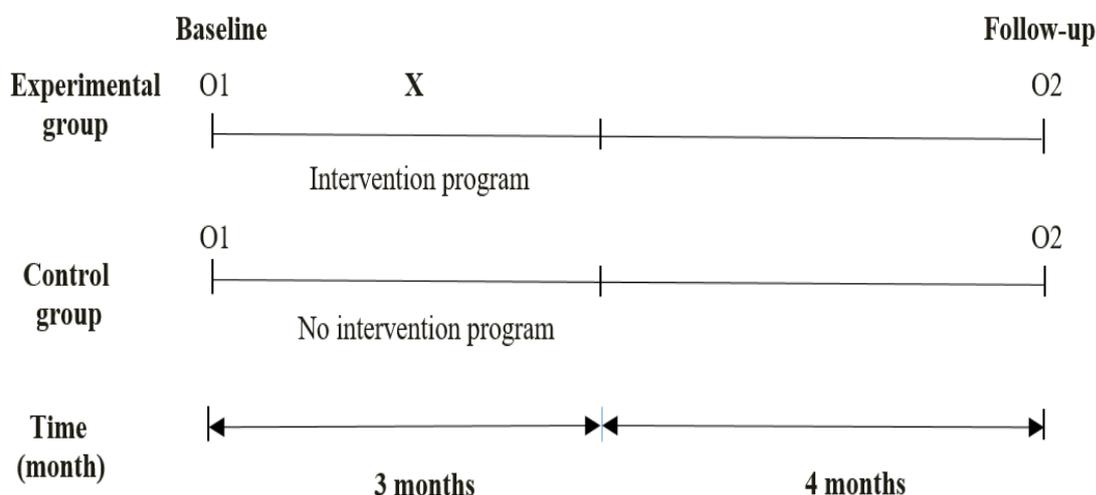


Figure 1 Research design

Note: O1, assessment of knowledge on the safe use of pesticides, and attitude related to pesticide use of participants in experimental group and control group before implementing intervention program; O2, assessment of knowledge on the safe use of pesticides, and attitude related to pesticide use of participants in experimental group and control group after the end of intervention program 4 month; X, pesticide application intervention program.

Six community health workers, known in Thailand as village health volunteers (VHVs), were involved in the study. Their duties were to visit the rice farmers' homes twice a month. During each home visit, if the VHVs found improper practice or unsafe work conditions, they had to suggest safety improvement ideas to the rice farmer. When a pesticide-related incident or illness occurs, VHVs are required to cooperate with a health care worker in the local health-promoting hospital to report and investigate the incident in order to identify the root cause and prevent similar incidents in the future. The selection criteria for VHVs were an education level above high school (Grade 9), 18–60 years of age, and no communication problems.

In addition, this study was done in collaboration with health care workers in subdistrict hospitals. The role of health care workers is that, in cases of pesticide poisoning, they must investigate the root of the incident and inform the farmer of its solution. If the incident was caused by the improper use of pesticides, the health care workers will advocate for proper behaviors when using pesticides, including collecting data and recording case information for further health surveillance.

For ethical considerations, this study protocol was approved by the Review Boards of the Ethical Committee of Srinakharinwirot University, Thailand (No. SWUEC 066/60 E). All participants were informed of the study objectives and had the right to withdraw from the study at any

time, which would not have any adverse effects on them.

Structure of the Pesticide Application Program

The pesticide application program was based on observation learning under the social cognitive theory (SCT),¹⁷⁻¹⁹ which uses the process of observational learning to create new behaviors. Additionally, a technique for training on the safe use of pesticides, called the fluorescent tracer manual,²⁶ was introduced as an approach to behavioral change and the reduction of health hazards in using pesticides. Additionally, a risk communication process and health surveillance procedure are boosters for increasing awareness of safety and efficient self-protection as well as the strict application of pre- and post-exposure risk mitigation practices, which are promoted through various communication channels to educate farmers on the dangers of pesticide toxicity, the ways it can enter the body, and its impacts on their health, families, and environment. Moreover, a systematic and continuous surveillance was in place to monitor the health situation of pesticide use. Thus, we applied a risk communication process and a health surveillance procedure, modified for the study setting. The intervention program consisted of the following three elements over a three-month period: (1) knowledge and training, (2) risk communication, and (3) health surveillance, as shown in Figure 2.

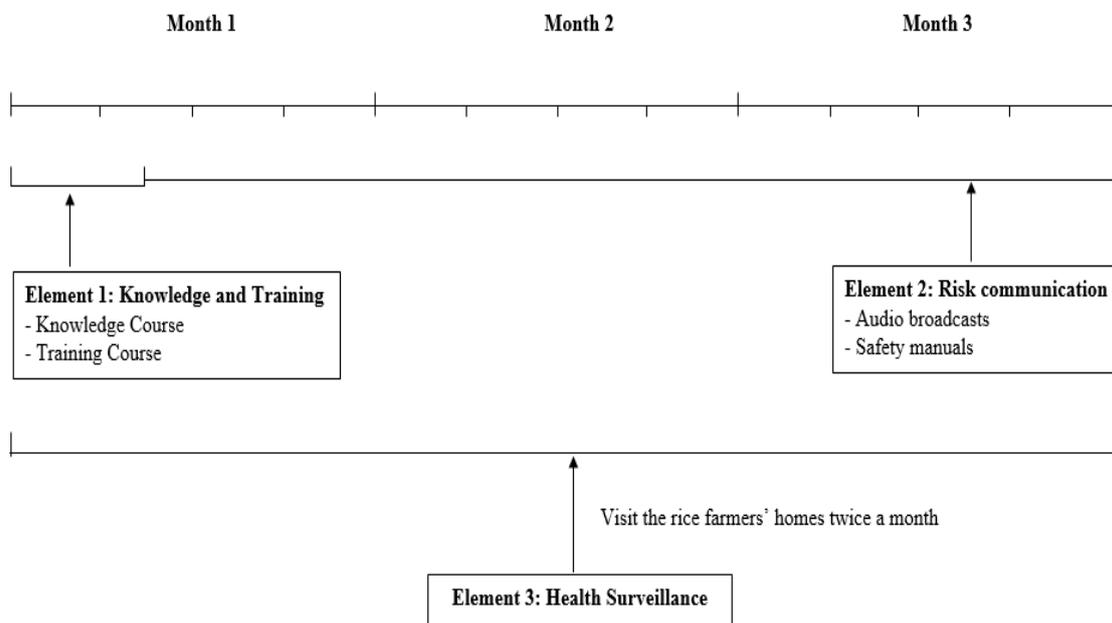


Figure 2 Structure of the Pesticide Application Program

Element 1: Knowledge and Training

The two-part program consisted of a knowledge course (days 1–2) and a training course (days 3–4). The program details are as follows:

(1) Knowledge Course

Day 1: The content consists of pesticide utilization and problems in Thailand, types of pesticides, their classification and hazards, the route of exposure, the impact of pesticides on health and the environment, and pesticide-related symptoms.

Day 2: The content comprises information on pesticide labeling, guidelines for the safe use of pesticides, appropriate personal protective equipment (PPE), first aid for pesticide poisoning, and the patient transfer system.

(2) Training Course

Day 3: The content includes demonstrations on the fluorescent tracer that is used to mark the areas where pesticides get on the skin and clothes, and it is applied as it is invisible under normal

lighting. Unlike pesticides, fluorescent tracers glow under a special lamp called a “black light” to show areas of contamination. As a result, the fluorescent tracer technique can provide a clear picture of pesticide contamination on the skin, with seven quick demonstrations in an operation room and the dark room, (1) using a baseball cap, (2) unplugging a spray nozzle, (3) using dirty fruits and vegetables, (4) shaking hands, (5) improperly removing PPE, (6) cell phone-cigarettes, and (7) applying pesticide formulations.

Day 4: This involves actual applications as done in normal practice, with a fluorescent tracer added to the pesticides.

Element 2: Risk Communication

We applied a risk communication process by informing the rice farmers about pesticide hazards, how it could affect their health, and how to protect themselves. We provided a program to be broadcast in the early morning and afternoon. There were 14 audio broadcasts related to safety at work,

each lasting for 3–6 min. We also provided three safety manuals that clearly explained the details to the participants. The contents of the safety communication were related to general knowledge about pesticides; risk behaviors in pesticide use among rice farmers; choosing and buying pesticides; uses of sprayers; maintenance, transportation, storage, and destruction of toxic substances and their containers; practices; and first aid for pesticide poisoning.

Element 3: Health Surveillance

The rice farmers must immediately report to the VHV all incidents or illnesses related to pesticide use, whereupon the VHV are to inform health care workers of every case. The following steps should be taken: (1) seek medical attention; (2) complete a medical treatment form; (3) investigate and identify the causes of pesticide-use incidents or illnesses at work, with health care workers using the results to improve pesticide safety, prevent harmful incidents, and reduce risks; (4) communicate to rice farmers why incidents and illnesses occur and the important role that farmers play in correcting their actions at work; (5) commit to continuous improvement and provide performance feedback. These steps will help the rice farmers to take appropriate actions to prevent future incidents related to pesticide use.

Data analysis

The Statistical Package for the Social Sciences (SPSS) for Microsoft Windows, version 20 (IBM Corporation, Armonk, NY, USA), was used for statistical analysis. Descriptive statistics were used to describe the mean, frequency, percentage, standard deviations of the general data. An independent t-test in the continuous data and a chi-square test in the categorical data

were performed to compare baseline differences in both independent and dependent variables, with the cutoff point for inclusion at $p < 0.05$. The intervention effect was assessed by measuring the rice farmers' 1) knowledge on the safe use of pesticides and 2) attitude related to pesticide use. The general linear model repeated-measure analysis of variance (ANOVA) was used to generate the figures by group and time. Statistical significance was defined as $p < 0.05$.

RESULTS

Participants' characteristics

In total, 74 rice farmers participated in this study, with 37 in the intervention group and 37 in the control group. There were slightly more females than males in the intervention group and slightly more males than females in the control group. The mean age was 55.3 years, ranging from 55 to 59. Most of them had graduated from primary school. Most of the rice farmers had a monthly family income in the range of 5,001–10,000 Thai baht (approximately US \$167–333). The participants who were smokers constituted 12.2%. The length of time working in rice farming averaged 29.0 years. The work hours per day averaged 6.5. The participants had an average farm size of 29.0 rai (or 11.7 acres).

Comparison of baseline characteristics

Table 1 shows no significant differences in the participants' characteristics between the intervention group and the control group. At the baseline, knowledge on the safe use of pesticides and attitude related to pesticide use were not significantly different between the two groups (Table 2).

Table 1 Participant characteristics at baseline (n = 74), by intervention status

Characteristic	Intervention group (n=37)		Control group (n = 37)		P-value
	n	%	n	%	
Gender					
Male	18	48.6	19	51.4	0.500 ^a
Female	19	51.4	18	48.6	
Age (group)^f					
45-49 years	5	13.5	6	16.2	0.741 ^a
50-54 years	5	13.5	7	18.9	
55-59 years	27	73.0	24	64.9	
Marital status					
Single	10	27.0	4	10.8	0.201 ^a
Married	21	56.8	25	67.6	
Widowed/Divorced/Separated	6	16.2	8	21.6	
Education					
Never attended school	-	-	2	5.4	0.371 ^b
Primary school	35	94.6	32	86.5	
Secondary school	2	5.4	3	8.1	
Monthly family income (Thai baht)^d					
≤ 5,000	7	18.9	9	24.3	0.768 ^a
5,001 - 10,000	22	59.5	19	51.4	
> 10,000	8	21.6	9	24.3	
Smoking habits					
No	34	91.9	31	83.8	0.479 ^b
Yes	3	8.1	6	16.2	
Characteristic					
	Mean	SD	Mean	SD	
Age (years)^f	55.03	4.14	55.62	3.65	0.515 ^c
The length of time working in rice farming (years)	28.81	6.14	29.22	7.76	0.804 ^c
Working hour per day	6.95	2.55	6.14	1.92	0.126 ^c
Farm size (rai)^e	21.78	13.36	22.38	9.02	0.823 ^c

Notes: ^a Chi-square test, ^b Fisher's exact test, ^c Independent t-test, ^d 30 Thai baht was approximately \$US1, ^e 2.47 rai = 1 acre, ^f Participants' ages in age (group) and age (years)

Table 2 Mean of knowledge on the safe use of pesticides, and attitude related to pesticide use at baseline (n = 74), by intervention status

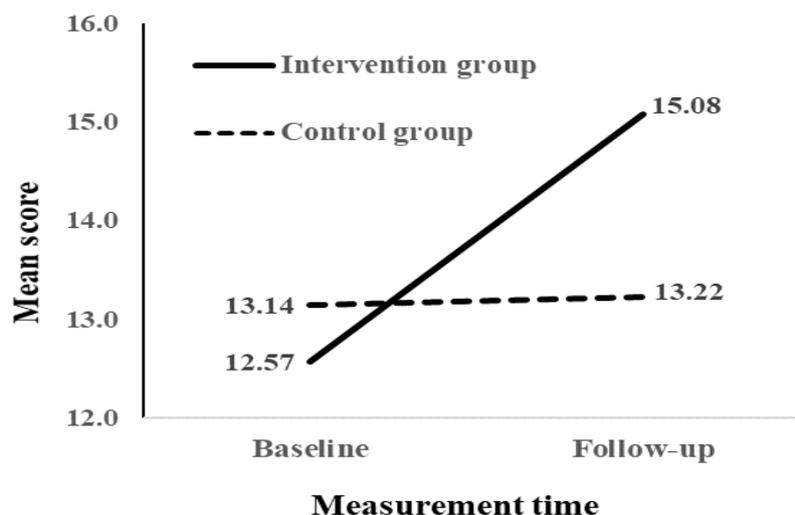
Variables	Intervention group (n=37)		Control group (n = 37)		P-value ^a
	Mean	SD	Mean	SD	
Knowledge on the safe use of pesticides	12.57	2.76	13.14	2.10	0.323
Attitude related to pesticide use	67.03	8.07	68.89	7.98	0.321

Note: ^aIndependent t-test

Effectiveness of pesticide application program

The pesticide application program's effect on knowledge on the safe use of pesticides indicated that the mean knowledge of the intervention group (12.57 points) was lower than that of the control group (13.14 points) at the baseline. At the follow-up, the mean knowledge on the safe use of pesticides had increased to 15.08 points in the intervention group and

increased slightly to 13.22 points in the control group (Figure 3). Regarding the pesticide application program's effect on the attitude related to pesticide use, in the intervention group, the mean attitude (67.03 points) was lower than in the control group (68.89 points). At the follow-up, the mean attitude in the intervention group had increased to 79.19 points and increased slightly to 70.81 points in the control group (Figure 4).

**Figure 3** Mean knowledge on the safe use of pesticides scores by intervention status and measurement time, before and after intervention

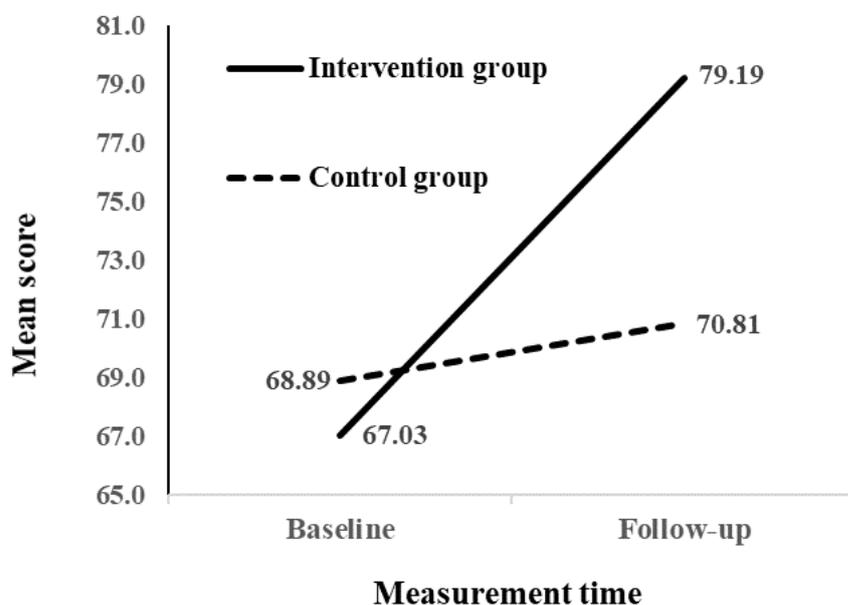


Figure 4 Mean attitude related to pesticide use scores by intervention status and measurement time, before and after intervention

The pesticide application program had effectively improved the intervention group's knowledge on the safe use of pesticides and attitude related to pesticide use at follow-up compared with the mean score at the baseline. At the follow-up, the intervention program on knowledge on the safe use of pesticides had effected an increase from the baseline score of 18.91%. The attitude related to pesticide use also

increased from the baseline score of 15.07%. After the applied intervention program, the results of the general linear model repeated-measure ANOVA showed that the intervention group had statistically different scores on its knowledge on the safe use of pesticides and attitude related to pesticide use compared with the control group, as shown in Table 3.

Table 3 Intervention effects and effectiveness of the program on knowledge on the safe use of pesticides, and attitude related to pesticide use

Variables	Overall mean at baseline	Intervention effects		Effectiveness of the program	
		Absolute magnitude	Proportion of baseline mean ^a	F	P-value ^b
Knowledge on the safe use of pesticides	12.85	2.43	18.91	28.147	<0.001
Attitude related to pesticide use	67.96	10.24	15.07	96.400	<0.001

Note: ^a Proportion of baseline mean as percent of baseline mean points, ^b General linear Model repeated measures ANOVA, Wilks' Lambda from multivariate test (p-values were identical to those in the ANOVA test of within-subject effects).

DISCUSSION

The results demonstrated that the pesticide application program which applied the social learning theory, risk communication, and health surveillance, allowed the participants in the intervention group to gain a better understanding of pesticides and achieve higher average pesticide knowledge scores, as well as improved attitudes toward pesticide use, after the intervention program. All of the gains had statistical significance. Our findings are consistent with those of the relevant study by Boonyakawee et al,²⁴ who conducted an intervention to reduce insecticide exposure among Shogun orange farmers in Thailand. As indicated in their results, the intervention was associated with substantial and statistically significant improvements in both knowledge score and attitude score at each follow-up time. Our findings were consistent with those of Suratman et al,²⁷ who found that educational interventions improved the farmworkers' knowledge and perceptions of pesticide exposure. This is also consistent with the findings on an intervention to reduce pesticide exposure among Thai rice farmers by applying the social learning theory; the intervention program significantly increased the farmers' safety knowledge²⁸. Similarly, a previous study by Jørs et al,²⁹ who evaluated the Bolivian small holder farmers' training on pesticide handling and ecological alternatives to reduce the negative pesticide effects, showed a sustained improvement of farmers' knowledge and personal protection and hygiene when handling pesticides. This is similar to the results of a previous study in a northern province of Thailand,³⁰ which reported an effective intervention program comprising awareness raising and the

creating awareness about occupational hazards.

The pesticide application program improved the rice farmers' knowledge on the safe use of pesticides and attitudes related to pesticide use. This is partly because the program included training that demonstrated, by employing the fluorescent tracer technique, how pesticides left chemical residues after their use. This also allowed the participants to gain awareness of how pesticides could enter human bodies, as well as the risks of exposure to pesticides. Additionally, risk communication may have played a role in making them realize the effects of pesticides on human health and the importance of safely using pesticides, including appropriate equipment use to prevent possible dangers. Another crucial aspect that contributed to the program's success was health surveillance, where VHVs, along with public health officials, reported cases of people suffering from pesticide-related conditions. This helped facilitate the exchange of knowledge within the community. The VHVs were accepted by the community and allowed access to the rice fields. They served as mediators between the public health officials and the locals, giving useful advice and communicating information; this could give rise to a preventive culture against pesticides. They also recorded cases of pesticide exposure in a timely manner.

Our study's limitation should also be noted. We evaluated the effects of the intervention program by comparing the scores of mean knowledge and attitude four months after the intervention. The results might differ with a longer follow-up time. Additionally, we were unable to measure other external factors that potentially influenced the knowledge and attitude of the participants. To illustrate, the intervention program contained an element

of risk communication, but we could not ascertain whether the participants had received -safety information from other channels, such as television and the internet, which could also affect the level of knowledge and attitude.

Knowledge and attitude toward pesticides are mutually connected and linked to the practice of using pesticides^{14,31}. This study focused on the knowledge and attitude related to pesticide use because the previous study had found that farmers in the study area lacked knowledge and understanding and had a negative attitude toward the safe use of pesticides. Nevertheless, the results of this research indicate an improvement in the level of knowledge and attitude after participating in the intervention program. Further study is therefore needed to see how farmers practice. An interesting intervention program to improve behavior would involve the researcher taking into account the continuity of action by encouraging the people in the community to get involved in developing a mechanism for tackling the problem in the form of participatory action research.

Although this program improved the outcome, it was associated with a phenomenon that merits consideration: health workers and VHVs are normally responsible for the health program, but an increase in their responsibility caused a delay in the process, especially in recording. Thus, researchers wishing to work in this industry may need incentives to participate and may need to cultivate enthusiasm among the relevant health workers. In addition, those who are interested in pesticide intervention programs should study the health effects of pesticide symptoms in order to find ways to reduce the impact on farmers' health. Our recommendation for practice is educating farmers aged 45–59 to be aware of the health impacts of using pesticides as well as promoting the participation of the rice

farmer community's health leaders and local health workers to jointly built a health surveillance system that enables communities to continuously promote the safe use of pesticides.

CONCLUSION

This study evaluated the effects of an application program among rice farmers. Taking the perspective of social cognitive theory, the program employed observation learning and comprised three elements over a three-month period: (1) knowledge and training, (2) risk communication, and (3) health surveillance. The results demonstrate that the participants in the intervention group had greater knowledge of pesticide use and better attitudes toward pesticide use than those in the control group. The findings can be reasonably generalized to rice farmers with similar characteristics, especially in the central region of Thailand.

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