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An Occupational Health Education Program for Thai Farmers Exposed to Chlorpyrifos

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Abstract

The majority of the farmers in this sample of Thai farmers did not use sufficient self-protective behaviors when using the organophosphate insecticide chlorpyrifos. Most were directly exposed to chlorpyrifos, potentially leading to illnesses. The aim of this study was to improve safety behaviors when using chlorpyrifos by an occupational health education program. A controlled trial (n = 70) of an occupational health education program was undertaken in rural Thailand prior to the occupational health education program. There were no differences in behavior between experimental and control groups. Completion of the program led to a significant improvement in safe working practices and in the amount of the metabolite. However, significant differences were noticed after participating in the occupational health education program on both safety behaviors and the amount of the metabolite 3,5,6-trichloro-2-pyridinol present in urine.

Keywords

chlorpyrifos, farmer safety checklist, occupational health education, safety behaviors, TCP metabolite

Introduction

Many farmers in the Asia-Pacific region, including in Thailand and Vietnam, are exposed to the organophosphate insecticide chlorpyrifos.[1,2] In Thailand, approximately 22.3 million acres of the total are under cultivation,[3] with rice being the major crop for both domestic consumption and export.[4] Large quantities of chlorpyrifos are used to protect crops from insects and maintain productivity.[5] Current consumption of chlorpyrifos imported to Thailand is estimated at 2000 tons per year.[6] Chlorpyrifos is categorized in Class 1A as a hazardous organophosphate insecticide.[7] It suppresses the enzyme acetylcholinesterase,[8] causing typical symptoms of toxicity. These include neurological and muscular symptoms, nausea and vomiting, dizziness,[9] fecal and urinary incontinence, bronchospasm, muscle paralysis, seizures, and unconsciousness.[6] Chronic exposure to

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chlorpyrifos results in chronic dermatitis, pulmonary fibrosis,[10] type 2 diabetes mellitus,[11] Parkinson's disease,[12] mental disorders, depressive disorders, and fetal abnormalities. The incidence of illnesses caused by chlorpyrifos exposure is estimated to be 12.25 per 100 000 people (in Thailand) and has been increasing on a yearly basis.[13]

On average, farmers are exposed to chlorpyrifos for 26 days every year.[14] Some farmers use larger amount of chlorpyrifos than the recommended quantity, and sometimes they mix chlorpyrifos with other pesticides. Most do not wear personal protective equipment, especially gloves (64%).[15,16] The level of blood cholinesterase enzyme among farmers was found at an unsafe level in one third of farmers.[6,13] Previous studies have shown that modification of self-protective behaviors can protect from the dangerous consequences of pesticides.[6,14,17] Apart from behavioral adjustments, several studies emphasize detecting biomarkers from the exposure of chlorpyrifos.[2,18-20] If chlorpyrifos is absorbed into the body, it is excreted in the urine (96%) as metabolite TCP (3,5,6-trichloro-2-pyridinol).[21] Accordingly, TCP is used as a specific biomarker for chlorpyrifos exposure.[17]

Farmers typically do not use self-protective behaviors when using chlorpyrifos and most are directly exposed, leading to symptomatic illness.[5] In this study, an occupational health education program based on the theory of the health belief model for behavior modification was used to study safety behaviors and decrease health effects.

The objective was to study the effectiveness of an occupational health education program to improve the safe handling of chlorpyrifos in Thai farmers in Suphanburi Province.

Methods

A controlled trial of an occupational health education program was undertaken on a sample of 70 farmers in the Suphanburi Province of Thailand. They were purposively sampled (province, district, and subdistrict, respectively) with the following required inclusion criteria: male aged 18 to 59 years who had used chlorpyrifos for more than a year, and no underlying diseases, including diabetes and kidney diseases. The subjects were randomly divided into experimental and control groups (n = 35 each). The authors provided a health education program based on the framework of the health belief model[22] to the experimental group for 4 weeks in May 2017, the period when chlorpyrifos was prevalent. Every subject completed a questionnaire related to chlorpyrifos usage at the preexperiment, postexperiment, and follow-up periods at weeks 1, 2, and 4, respectively. Urine samples were collected at the time the questionnaires were administered.

The occupational health education program was applied based on the health belief model consisting of 2 activities: (1) activities for providing a perceived susceptibility and severity of chlorpyrifos use and (2) activities for providing perceived benefit and barriers of self-protection in using chlorpyrifos. See Table 1 for details.

Urine samples were collected from the subjects at weeks 1, 2, and 4 in the early morning of the day (first urine, 24 hours), after dealing with chlorpyrifos. Urine samples were individually collected in a 15-mL centrifuge tube with screw cap (polypropylene, HYCON brand, Bangkok, Thailand). Samples were kept at −18°C[23] and sent to the Laboratory and Toxicology Reference Center, Bureau of Occupational and Environmental Diseases, Department of Health, Ministry of Public Health, Thailand, using 1°C to 2°C coolers for analysis.

The method for extracting metabolite TCP in urine was modified from Meuling et al[19] who analyzed derivatized TCP by using a Model 7890A Agilent, a Model 7683B Injector Agilent, and a Model 5975C Detector Agilent. Gas chromatography–mass spectrometry device conditions were prepared for analyzing metabolite TCP. Monitored ion (m/z) was used to investigate mass ions of hexachlorocyclohexane (internal standard). Sim modes were at 181 and 183 (m/z). Mass ions of derivative substances of metabolite TCP were determined at 254 and 256 (m/z) with a

Table 1. Activities From Chlorpyrifos Safety Checklist and Occupational Health Prevention Program.

Principles	Activities	Time (Hours)
Perceptions of susceptibility and severity of chlorpyrifos use	• Informing blood cholinesterase enzyme level individually and chlorpyrifos safety checklist in order to assess risks in each stage of rice farming and hold group discussions on incidence of illnesses caused by chlorpyrifos. • Providing information on toxicity, channels of contact, and dangers from chlorpyrifos with PowerPoint presentations. • Using the results from the farmers' safety checklist to determine the severity of potential effects on farmers' health.	2.5
Perceptions of benefits and barriers in self-protection against chlorpyrifos	• Explaining benefits from self-protection when exposing to chlorpyrifos and benefits from using personal protective equipment with PowerPoint presentations and demonstrations of personal protective equipment usage to help subjects perceive the benefits of self-protection against chlorpyrifos. • Group discussions on "reasons and guidelines for solving problems that prevent self-protection when using chlorpyrifos."	1.5

limit of detection of 5.4 μg/L. Limit of quantification was found at 13.4 μg/L. R^2 was equal to .997. Creatinine in urine was determined using Jaffe's Kinetic Method[24] by the Bureau of Occupational and Environmental Diseases, Department of Disease Control, Ministry of Public Health, Thailand.

This study was approved by the Ethical Review Committee for Research in Human Subjects, Burapha University, Thailand (Approval Number 2/2560).

Results

The age characteristics of the subjects were similar in the experimental and control groups, with a mean age of 44 years. The use of chlorpyrifos by both groups was similar with use of approximately 12 years for 8 times/month, and 3 hours/time (Table 2). Before participating in the occupational health education program, there was no difference in the safety behavior scores of farmers between the experimental and control groups. However, the experimental group had received the education program, and there was a significant difference between the experimental and control groups ($P < .05$). Similarly, there was no difference in the metabolite TCP in urine prior to participating in the occupational health education program, while the farmers in the experimental groups had a significantly reduced level of TCP in their urine ($P > .05$). See Tables 3, 4, and 5. The differences persisted in the follow-up period.

Discussion

The strength of this study was the design of the study as a randomized controlled trial that included assessment of the biomarker TCP that confirmed the success of the education program. The present study indicated that the farmers had significantly different safety behaviors after the intervention and after the follow-up period. This was because the program focused on raising awareness in 4 areas, an explanation of blood cholinesterase enzyme levels from individual health books and the safety checklist, information on susceptibility to chlorpyrifos toxicity used at each stage of rice farming, and details of potential health impacts. The authors organized the group discussions on health threats from using chlorpyrifos, ways the farmers could avoid risky behaviors, and how to implement protective behaviors.

Table 2. Background Characteristics of the Thai Farmers.

Characteristics	Experimental Group	Control Group	*t*	χ^2	*P*[a]
Age (years)					
Mean ± SD	44.8 ± 3.3	44.3 ± 2.9	.557		.57
Education				1.0	.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 most recent use in chlorpyrifos (years)					
Mean ± SD	12.3 ± 5.9	12.4 ± 5.7	−.041		.97
Frequency of using the chlorpyrifos (months)					
Mean ± SD	8.6 ± 9.5	9.0 ± 8.5	−.199		.84
Duration of applying to chlorpyrifos (hours)					
Mean ± SD	3.3 ± 1.3	3.2 ± 1.3	.273		.79

[a]*t* test, χ^2 test.

Table 3. Descriptive Statistics of Scores of Safety Behaviors in Using Chlorpyrifos and Metabolite TCP (3,5,6-Trichloro-2-Pyridinol) in Urine Between the Experimental and Control Groups.

Variables	Experimental Groups (n = 35)	Control Groups (n = 35)	*P*[a]
Scores of safety behaviors in using chlorpyrifos			
Before yes	1.5 ± 0.5	1.5 ± 0.5	1.00
After yes	3.3 ± 0.4	1.5 ± 0.5	<.05
Follow-up yes	4.0 ± 0.4	1.5 ± 0.5	<.05
Amount of metabolite 3,5,6-trichloro-2-pyridinol			
Before yes	29.3 ± 7.9	28.4 ± 8.3	.36
After yes	17.5 ± 3.9	31.4 ± 7.0	<.05
Follow-up yes	12.4 ± 5.3	38.4 ± 7.8	<.05

[a]*t* test.

Table 4. Comparison of Safety Behaviors in Using Chlorpyrifos Means Between the Experimental and Control Groups at Preexperiment, Postexperiment, and Follow-up Periods.

Variables	SS	df	MS	*F*[a]	Observed Power[a]
Safety behaviors in using chlorpyrifos means between the experimental and control groups: between subject treatment					
Group	531.22	1	531.22	4122.7*	1.00
Error	8.76	68	0.13		

Abbreviations: SS, sum of square; df, degree of freedom; MS, mean square.
[a]Greenhouse's Geisser correction was used to reduce type error.
**P* < .05.

The authors explained the advantages of personal protective equipment in reducing exposure to chlorpyrifos until the subjects understood and perceived the benefits of the activities. In addition, the farmers were able to select acceptable practices for modifying their protective behaviors as evidenced in field visits. During the follow-up period, the subjects had better

Table 5. Comparison of Differences in Mean Metabolite TCP in Urine Between the Control and Experimental Groups.

Variables	SS	df	MS	F^{a}	Observed Power[a]
Average metabolite TCP: between subject treatment					
Group	7316.83	1	7316.83	57.17*	1.00
Error	8703.71	68	127.99		

Abbreviations: TCP, 3,5,6-trichloro-2-pyridinol; SS, sum of square; df, degree of freedom; MS, mean square.
[a]Greenhouse's Geisser correction was used to reduce type error.
*$P < .05$.

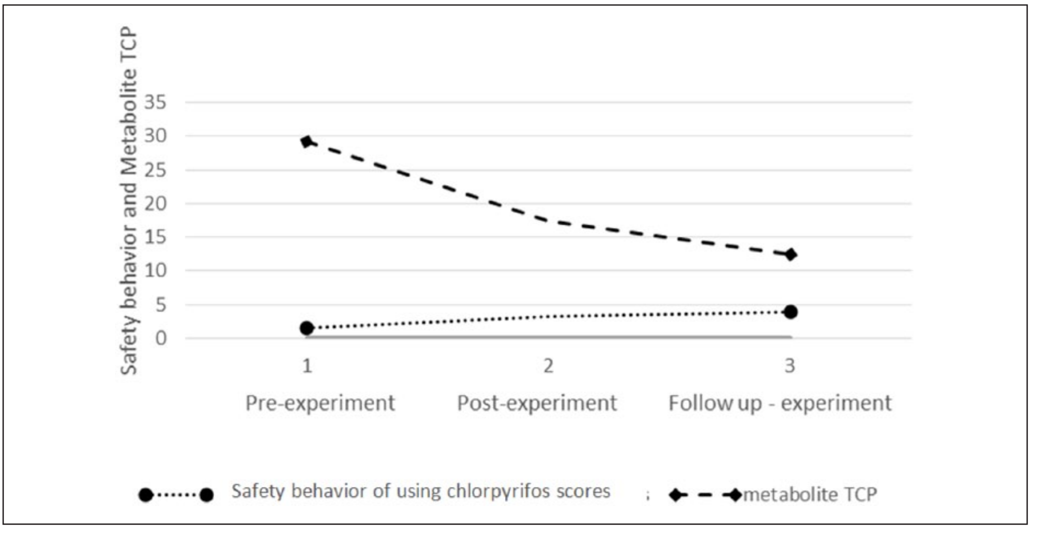

Figure 1. Comparison between safety behavior in using chlorpyrifos means and metabolite TCP (3,5,6-trichloro-2-pyridinol) at each period of experimental group.

self-protective behaviors, using personal protective equipment before, during, and after mixing and applying chlorpyrifos without being reminded by the authors.

This corresponded with the study of Suratman et al[25] who studied the effectiveness of an educational intervention, using the framework of the health belief model[22] to improve perceptions on a reduction of organophosphate exposure among Indonesian and South Australian migrant farm workers. They found the significant improvement of using self-protective behaviors ($P < .05$). The program in this study applied the health belief model by raising the perceptions in 4 areas, including susceptibility, severity, benefit, and barriers. The farmers complying with that program had improved self-protective behaviors.

The present study was also consistent to the findings of Raksanam et al,[26] as well as Markmee et al[20] reporting that the farmers had significant differences using self-protective behaviors after education programs ($P < .001$). Likewise, Santaweesuk et al claimed that the disease prevention programs are important to safety behaviors of farmers.[27]

The amount of metabolite TCP level in urine was measured from participants using chlorpyrifos before and after the intervention and again in the follow-up period (week 4). The farmers in the experimental group had significantly less exposure to chlorpyrifos and lower mean TCP levels than those in the control group ($P < .05$). The results showed that the program reduced the exposure to chlorpyrifos and the amount of TCP in urine (Figure 1). This was in agreement with a study of Jagt et al[28] reporting that the experimental group had less exposure to chlorpyrifos and lower level of metabolite TCP at the preexperiment period than the control group. Correspondingly, the study by Griffith et al suggested that the program could significantly help reduce the exposure to pesticide and the amount of pesticide metabolite in urine.[16] Furthermore, a study from the United States revealed that the promotion of pesticide knowledge for indigenous farm workers in Oregon could help reduce organophosphate metabolite in urine of the intervention group significantly.[29]

There are several limitations that need to be considered when interpreting the results of this study. The study sample is relatively small, and while it is considered to be typical of rural Thailand, similar studies may be useful in other geographic areas. The study is of relatively short duration, and further tests should be undertaken after 1 and 2 years to see if the benefits of the program are lasting.

Conclusion

This study showed that the occupational health education program was of benefit for Thai farmers exposed to chlorpyrifos. The benefits of the program were demonstrated in behavioral changes and also in the level of the metabolite excreted in the urine.

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Declaration of Conflicting Interests

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