INSECTICIDE USE, PROTECTIVE BEHAVIOR, SERUM CHOLINESTERASE LEVELS, AND HEALTH EFFECTS AMONG RICE FARMERS IN KONGKRAILAT DISTRICT, SUKHOTHAI PROVINCE, THAILAND

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ABSTRACT: The objective of this cross-sectional analytical research was to identify and assess the health effects of insecticide use among rice farmers, including socio-demographic factors, insecticide use history, knowledge, attitude, self-protective behaviors, serum cholinesterase (SChE), and pesticide-related symptoms among 182 rice farmers in Kongkrailat District, Sukhothai Province, Thailand. The data were collected using standardized, pre-tested questionnaires. The subjects were selected by multi-stage sampling carried out in January 2012. Descriptive statistics were presented as percentage, mean, and standard deviation (S.D.). Chi-square statistics were calculated to examine the relationships between the variables. The study results showed that 53.3% of the subjects were female, the average age was 45 years, the average farm size was 14.5 acres, 95.6% had never been trained in safe use of pesticides, the average number of years of mixing or applying pesticide was 16.5 years, the average number of days used were 36.8 days, the duration of each spraying was an average of 3.46 hours, and 91.2% mixed pesticides of ≥3 kinds. The insecticides used were organophosphate group: chlorprifos (93.4%); carbamate group: methomyl (68.1%); pyrethroid group: cypermethrin (52.2%); and avermectin group: abamectin (98.9%). Furthermore, 57.7% had high knowledge level, while 51.1% had low-level attitude regarding safe use of pesticide. Total protective behavior scores were 69, which were divided into three groups: when mixing, when applying, and after using pesticides. The mean score was used to separate low and high levels. Most of the subjects had high-level score when mixing (57.1%) and after using (69.2%), and low-level score when applying (51.1%).The SChE levels were measured by reactive paper from Ministry of Public Health, and divided into four levels: normal, safe, risky, and unsafe. We found that 97.8% of the subjects come under risky or unsafe levels. The health effects were measured as self-reported pesticide-related symptoms during or within 24 hours after application of pesticide, including five organ systems: neuromuscular, respiratory, digestive, eyes, and skin. We found that 86.8% of the subjects had pesticide-related symptoms. Most of the symptoms were neuromuscular (79.1%). Furthermore, attitude, SChE levels, and protective behavior were found to be associated with pesticide-related symptoms. Thus, these findings suggest that health promotion should be concerned about protective behaviors, and that rice farmers need intervention to improve protective behaviors and reduce health risk of pesticide use.

Keywords: insecticides, protective behavior, health effects, serum cholinesterase, rice farmers

INTRODUCTION

Thailand is currently the leading country in exporting rice products to the world market [1]. Two types of pesticides are mostly used, namely insecticide (51%) and herbicide (38%). The use of pesticides is one of the methods that farmers choose to control pests, and pesticide usage has increased in Thailand. The agrochemical expenses from 2006 to 2009 were 10,530, 12,898, 15,062, and 19,181 million Baht per year, respectively, and the volumes of agrochemical imports were as high as 75,473, 95,763, 116,322, and 109,907 tons per year, respectively [2].

On reviewing various data from the past to present, it was found that the Thai farmers, especially the rice farmers, still use pesticide inappropriately. Statistics from the Ministry of Public Health on occupational poisoning show some decreasing number from a high of 5154 in 1989 to 3165 in 1994, although there has been no change in the type of pesticides used or the application of technology. The study estimated that there could be up to 39,600 pesticide-poisoning cases per year [3].

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Researchers found that approximately half of Thai farmers employ pesticides in higher dose than the recommended concentrations, unduly frequently, without protective clothing [3]. The use of pesticide is largely directed by self-behavior. In "political environment in which regulations do not cover how farmers apply pesticides, it is important to know what drives farmer's voluntary behavior of pesticide use" [4]. Most of the pesticides are used in rice farming. The rice farmers use them with their expectation to kill insect and grass, protect their crops, and get more benefit from the crops. Particularly, insecticide is a major biological class used in the rice farm [5], which induced this researcher's interest in insecticide use among farmers, especially rice farmers. Accordingly, there are two main objectives: to assess health risk of insecticide use, including insecticide use history, knowledge, attitude, protective behaviors, cholinesterase level, and insecticide-related symptoms among rice farmers, and to examine association between some factors that influence the famers practicing these behaviors and history of insecticide poisoning.

MATERIALS AND METHOD

This research was a cross-sectional study, which examined the socio-demographic characteristics, insecticide use, protective behaviors, and their relationship with insecticide-related symptoms in rice farmers. The target population of this research was all rice farmers living in Kongkrailat district, Sukhothai province. The selection criteria were rice farmers who were at least 18–65 years of age and had ever applied insecticides at least one year. Multi-stage sampling was implemented for selecting the subjects. Previous studies were used to provide a basis for sample-size calculation and summarized reported rates of illness and symptoms, in relation to different exposure levels, as observed in these studies. Then, the sample sizes that were necessary to detect the observed differences were calculated. For specific calculation, data from Sorat's study [6] were used as a basis. The calculation was carried out using OpenEpi Version2, SSCohort (Confidence = 95%, Power = 80%), as well as 77.3 and 55.7% symptom prevalence with lower and higher exposure, respectively. This gave a sample-size requirement of 164 subjects. Moreover, 182 subjects were sufficient to detect most of the pesticide exposure related differences in symptoms and illness, which had been observed in previous studies. Questionnaires were developed from the studies by Sorat [6], Jariya [7], and the Agriculture Health Study of USA (AHS) [8].The research was explained to potential participants who indicated consent by returning the questionnaires. The instrument of this research was standardized questionnaire, which consisted of seven parts, including socio-demographic factors, insecticide use factors, knowledge, attitude, protective behaviors, serum cholinesterase (SChE) level, and insecticide-related symptoms. Protective behaviors comprised a total of 23 questions concerning the farmers practice in terms of the frequency to perform it. The levels of performing protective behaviors were categorized based on the mean cut point value as high and low. The serum was tested using reactive paper to determine the cholinesterase level. The test kit is produced by the Government Pharmaceutical Organization of Thailand. Its sensitivity is 77%, specificity is 90%, and positive predictive values are 85%. The measurements were divided into four categories –normal, safe, risky, and unsafe – and four levels of colors to determine the magnitude of change in cholinesterase activity through the production of acetic acid, as follows:

Reactive paper color	***Health status***	***SChElevel (units/ml)***
Yellow	Normal	≥ 100
Yellow-green	Safe	87.5 – 99.9
Green	Risky	75.0 – 87.4
Blue	Unsafe	< 75.0

This method is generally used to measure anti-cholinesterase by the Ministry of Public Health [9]. In the present study, the self-reported insecticide-related symptoms were categorized into five groups based on organ systems: neuromuscular, respiratory, digestive, eye, and skin. The questionnaires were pre-tested on 60 farmers in two villages that were not included in the sample. Pilot test was used for the clarity of questionnaires; if pilot subjects did not understand some words or had difficulty in answering, then the researcher would change them for clarity. Data collection was carried out in January 2012. Descriptive statistics, including frequencies and percentage, were used for socio-demographic factors, insecticide use behaviors, protective behaviors, and insecticide-related symptoms. Mean and Standard deviation (S.D.) of score were calculated for the socio-demographic factors, insecticide use behavior, knowledge, attitude, and protective behaviors, and Chi-square statistic was used to determine the relationship between the variables. For all the statistical tests used in this study, the statistically significant level was set at $p = 0.05$. This research was approved by ethical consideration committee of Chulalongkorn University.

Table 1 Socio-demographic characteristics (n = 182)

Demographic characteristics	*n*	(%)
Gender		
Male	85	(46.7)
Female	97	(53.3)
Age group (years)		
≤ 40	67	(36.8)
41 – 50	53	(29.1)
51 – 65	62	(34.1)
$\overline{X}$ = 44.62, SD.= 11.11, Min = 19, Max = 65		
Marital status		
Single	13	(7.2)
Married	162	(89.0)
Divorced/separated/widowed	7	(3.8)
Education level		
Illiterate or primary school	125	(68.7)
Secondary school (grade 7 – 10) $\bar{x}$	33	(18.1)
High school / > high school	24	(13.2)
Household size (persons)		
1 – 3 persons	55	(30.1)
4 persons	66	(36.3)
5-9 persons	61	(33.6)
$\overline{X}$ = 4.00, SD.= 1.52, Min = 1, Max = 9		
Family monthly income (Baht)		
< 10,000 baht	87	(47.8)
10,001 – 20,000 baht	61	(33.5)
>20,000 baht	34	(18.1)
Farm size (acres)		
≤ 10	65	(35.7)
10.01 – 20.00	82	(45.1)
> 20	35	(19.2)
$\overline{X}$ = 14.46, SD.= 9.42, Min = 0, Max = 51.40		
Ever been trained in safe pesticide use		
Never	174	(95.6)
Ever	8	(4.4)

RESULTS

The proportion of female subjects (53.3%) was slightly higher than that of male subjects, and most of the rice farmers (63.2%) were older than 40 years of age. The average age was 44 years and most of the subjects (89.0%) were married and had primary school level education (68.7%). Most of the subjects (66.4%) had household size of at least four persons and an average of 4 persons. Most of them (95.6%) had never been trained in safe use of pesticide. The average farm sizes were 14 acres, and 64.8% reported frequency of growing as two times per year; however, 6.0% were only pesticide applicator labors in the farms. Most of farm stats showed 45.3% were both owner and rent for areas.

The socio-demographic characteristics are summarized in Table 1. A total of 17.6% of the subjects were labors in the rice farms. With regard to insecticide use factors, most of the subjects (61.5%) had used insecticide as rice farmer for ≥10 years. However, the average time period of using insecticide was 16 years. Most of the subjects (53.9%) used pesticides for <15 days in the last year, with an average of 36.76 days. All of the subjects reported to have read the label before using pesticide, and most of them used pesticides in quantities less than or equal to that recommended. Furthermore, the duration of each spraying was 3.43 hours on an average.

The main method that the farmers used was spraying. Most of the subjects (92.1%) mixed three or more kinds of pesticides. In each application of pesticides, they applied at least one kind of insecticide, and most of them (98.8%) had duty in handling both mixing and applying. These characteristics are summarized in Table 2.

The pesticides used in rice farms come under five biological classifications, including herbicide, insecticide, fungicide, rodenticide, and biopesticide. Most of the WHO toxicology classes are moderately hazardous. In the study group, most of the herbicides used (94.0%) were glyphosate, and

Table 2 Pesticide use factors (n = 182)

Pesticide use factors	*n*	(%)
Duration of using insecticide as rice farmer (year)		
1 – 10 years	70	(38.5)
11 – 20 years	33	18.1)
20 – 36 years	79	43.4)
$\overline{X}$ = 16.51, SD.= 9.57, Min = 1, Max = 36		
Frequency of insecticide use in the last year (day)		
1 – 15 days	98	(53.8)
16 – 30 days	48	(26.4)
31 – 36 days	36	(19.8)
$\overline{X}$ = 36.76, SD.= 47.81, Min = 2, Max = 200		
Concentration of insecticide used		
Less than/same as recommended	112	(61.5)
More than recommended	70	(38.5)
Duration of each insecticide spraying (hours)		
1 – 3 hrs	107	(58.8)
4 –6 hrs	75	(41.2)
$\overline{X}$ = 3.46, SD.= 1.25, Min = 1, Max = 6		
The number of pesticides mixed for spraying		
Only one or two kinds	16	(8.8)
Three kinds or more	166	(92.1)
Duty in handling insecticides		
Both mixing and applying pesticides	182	(100.0)

Table 3 Insecticide use in rice farms by insecticide family name (n = 182)

Biological Classification/ Common name	Chemical family	WHO Toxicology class*	Carcinogen	Cholinesterase inhibitor	*n*	(%)
Chlorpyrifos	Organophosphates	II	Not likely	Yes	170	(93.4)
Phethoate	Organophosphates	II	-	Yes	55	(30.2)
Triazophos	Organophosphates	Ib	-	Yes	50	(27.5)
Omethoate	Organophosphates	Ib	-	Yes	33	(18.1)
Acephate	Organophosphates	II	Yes	Yes	28	(15.4)
Methomyl bromide	Carbamates	Ib	Not likely	Yes	124	(68.1)
Fenobucarb	Carbamates	II	-	Yes	30	(16.5)
Cabosulfan	Carbamates	II	-	Yes	25	(13.7)
Cartaphydrochloride	-	Not listed	-	No	19	(10.4)
Carbaryl	Carbamates	II	Possible	Yes	18	(9.9)
Cypermethrin	Pyrethroid	II	Possible	No	95	(52.2)
Abamectin	Abamectin	Not listed	Not likely	No	180	(98.9)

*WHO toxicology class: Ia= Extremely hazardous, Ib= highly hazardous, II = Moderately hazardous, III = slightly hazardous, and U = Unlikely to present acute hazard in normal use

most of the insecticides used (93.4%) were chlorpyrifos (Organophosphate), followed by methomyl bromide (carbamate) (68.1%), abamectin (98.9%), and cypermethrin (52.2%). Furthermore, most of the fungicides used (82.4%) were propiconazole. There were some pesticide classes that had carcinogen, such butachlor (herbicide) and acephate (insecticide), and organophosphate and carbamate in insecticides have cholinesterase inhibitor. These characteristics are summarized in Table 3.

Knowledge in pesticide use scores were developed based on each of its four aspects, and the mean score (15) was used to divide the subjects into two groups with high and low level (low level = 7–15, high level =16–19 scores). It was found that 57% had low-level scores.

Attitude scores were developed for each of the five aspects of attitude, and the mean score (85) was used to divide the subjects into two groups with high- and low-level scores. It was found that 61% had low-level scores. Protective behavior (practicing in terms of frequency) scores were developed for each of the four aspects: always, sometime, rarely, and never of self-protection behavior. Total protective behavior scores were 69, and were divided into three groups: when mixing (15 scores), when applying (36 scores), and after

Table 4 Knowledge, attitude, protective behaviors in pesticide use, and serum cholinesterase levels (*n* = 182)

Knowledge, attitude, protective behaviors, and serum cholinesterase level	*n*	%
Total knowledge (Maximum possible score = 20)		
Low (score 7 –15)	105	57.7
High (score 16 –19)	77	42.3
Mean = 15.6, SD = 2.2, Min = 7, Max = 19		
Total Attitude (Maximum possible score = 120)		
Low (score 54 – 85)	93	51.1
High (score 86 –106)	89	48.9
Mean = 85.5, SD = 9.7, Min = 54, Max = 106		
Protective behaviors when mixing (Maximum possible score = 15)		
Low (scores 7 – 12)	78	42.9
High (score > 12)	104	57.1
Mean = 12.6, SD= 1.9, Minimum = 7, Maximum = 15		
Protective behaviors when applying (Maximum possible score = 36)		
Low (scores 8 – 21)	93	51.1
High (score > 21)	89	48.9
Mean = 21.4, SD= 4.3, Minimum = 8, Maximum = 31		
Protective behaviors after using (Maximum possible score = 18)		
Low (scores 6 – 16)	78	42.9
High (score > 16)	104	57.1
Mean = 16.7, SD= 2.1, Minimum = 6, Maximum = 18		
Total protective behaviors (Maximum possible score = 69)		
Low (score 32 – 51)	91	50.0
High (score > 51)	91	50.0
Mean = 51, Minimum = 32, Maximum = 63		
Serum cholinesterase level		
Normal/safe (≥87.5 units/ml)	4	2.2
Risky (75.0 – 87.4 units/ml)	73	40.1
Unsafe (<75.0 units/ml)	105	57.7

Table 5 Insecticide-related symptoms during or after insecticide use by system organs (*n*=182)

Symptoms/Number of symptoms	Ever in last week		Ever in last month	
	n	(%)	*n*	(%)
Neuromuscular	106	58.2	144	79.1
Respiratory	87	47.8	120	65.9
Digestive	40	22.0	40	22.0
Eyes	63	34.6	63	34.6
Skin	52	28.6	76	41.8
At least one symptom	113	63.7	158	86.8
Number of symptoms (Maximum symptoms = 31 symptoms)				
Never	66	36.3	66	13.2
1 –5 symptoms	55	30.2	70	38.5
6 symptoms or more than	61	33.5	88	48.4
Ever in last week $\overline{X}$ = 5.25, SD.=6.61, Min = 0, Max = 27				
Ever in last month $\overline{X}$ = 7.27, SD.= 6.49, Min = 0, Max = 27				

using pesticides (18 scores). The mean score was used to divide the subjects into two groups with high- and low-level scores. Most of the subjects had high-level score when mixing (57.1%) and after using (69.2%) pesticides, and low-level scores when applying (51.1%) pesticides. Furthermore, most of them (97.8%) had SChE level at risky or unsafe, as shown in Table 4.

Health effects were measured based on insecticide-related symptoms that occurred during or 24 hours after application of pesticides, including 31 acute poisoning symptoms. These were organized into the following five categories: neuromuscular, respiratory, digestive, eyes, skin, and symptoms of any organ systems. The major neuromuscular symptoms were exhaustion (47.3%), respiratory symptoms including dry throat (55.5%), digestive symptoms including nausea (28.0%), eyes symptoms including burning-stinging-itchy eyes (36.8%), and skin symptoms including itchy skin (34.1%). Furthermore, 63.7% of the subjects had symptoms in the last week and 86.8% had

Table 6 Relationships between serum cholinesterase level and insecticide-related symptoms (*n*=182)

Symptoms	Serum cholinesterase level				χ^2	*p*
	Normal/safe/ risky (*n* = 77)		Unsafe (*n* = 105)			
	n	%	n	%		
Ever in last week						
Neuromuscular	34	32.1	72	67.9	10.89	0.001*
Respiratory	32	36.8	55	63.2	2.08	0.15
Digestive	8	20.0	32	80.0	10.45	0.001*
Eyes	22	34.9	41	65.1	2.15	0.14
Skin	17	32.7	35	67.3	2.76	0.10
At least one symptom	38	32.8	78	67.2	11.95	0.001*
Ever in last month						
Neuromuscular	55	38.2	89	61.8	4.78	0.03*
Respiratory	50	41.7	70	58.3	0.59	0.81
Digestive	8	20.0	32	80.0	10.48	0.001*
Eyes	22	34.9	41	65.1	2.15	0.14
Skin	28	36.8	48	63.2	1.60	0.21
At least one symptom	62	39.2	96	60.8	4.62	0.03*

* Significance level at < 0.05

symptoms in the last month. Most of the symptoms organs were neuromuscular symptoms. Subjects had average symptom occurred during or 24 hours after applying pesticide 5 symptoms in last week and 7 symptoms in last week, surprisingly about half of subjects had symptoms 6 symptoms or more than in last month shown in Table 5. SChE levels had relationship with neuromuscular, digestive, and other symptoms in the last week, and neuromuscular, digestive, and at least one symptom in the last month, as shown in Table 6. Attitude had relationship with neuromuscular (p=0.008), respiratory (p=0.045), digestive (p<0.001), eyes (p=0.001), and skin (p=0.038) symptoms within last week.

DISCUSSIONS

Pesticides used in rice farms have many biological classifications and common names, and it might be possible that the subjects might suffer from multi health effects of pesticide use by mixing three or more pesticides. The health risk of pesticide use might be acute and chronic health effects because some of pesticides use carcinogens or possible carcinogens, such as acephate, carbaryl, and cypermetrin [10]. In particular, some classes of pesticides have no information about health effects, such as abamectin. Most of the subjects had low level of knowledge, moderate attitude, and moderate protective behavior. However, some correlation was found between knowledge, attitude and practice scores and number of symptoms. The attitude levels were associated with the levels of the number of symptoms in the last month (p = 0.02) and last week (p = 0.002), in accordance with Sorat [6], who believed in the benefits of and barriers in taking action regarding pesticide use. Protective behavior had association with acute poisoning symptoms [11], and comprises some aspects, such as personal protective equipment, including use of mask, goggles, gloves, coverall, boots, and hat while applying pesticide. Most of the rice farmers had used few personal protective equipments; for example, when applying insecticide, 24.7% used masks, 33.5% used gloves, 11.0% used goggles, and 1.6% used coverall. To increase the scores of protective behaviors might use personal protective equipment. Surprisingly, 17.6% of the subjects were labors who used pesticides for more number of days than the other groups in the rice farms, and 81.4% of them had unsafe level of cholinesterase. The SChE level had association with symptoms, in accordance with Sirivarasai [12], and the relation between cholinesterase activity and symptoms showed significant evidence.

Limitation

This study did not evaluate all the biological classifications of pesticides, exposure, and health effects of pesticide use. The SChE levels were measured only with respect to neuromuscular system after exposure to insecticide of organophosphate and carbamate groups. Also, the study was carried out only in one of the nine districts of Sukhothai province, and hence, it might not be representative of the whole province or larger geographic areas, such as Thailand itself.

CONCLUSION

The research found that protective behaviors and

SChE levels have association with symptoms. Medical monitoring of cholinesterase inhibition should be carried out for pesticide exposures to perceive the health status, thus increasing their awareness, and intervention programs regarding safety practices during work are important issues aimed at minimizing the adverse health effects of pesticide.

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