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Health risks associated with pesticide exposure and pesticides handling practices among farmers in Thailand

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Abstract

One of the major public health problems in Thailand is pesticide intoxication, which is the result of intensive use of and exposure to pesticides. Smallholder farming is the main occupation that generates incomes for the population in Lampang province and the previous study found that the levels of serum cholinesterase (SChE) of blood's farmers were at high risk of exposure to pesticide at 82%. The objectives of this study were to investigate the pesticide practices of farmers and their symptoms, the health risks of exposure to pesticides, SChE levels and the relationship between demographic characteristics and pesticides practices, health risk levels and the health statuses of farmers, who are exposed to pesticides in Muang district, Lampang province, in Northern Thailand. A cross-sectional study was conducted from June 2019 to August 2020. Data were collected from 416 farmers using a structured face-to-face interview questionnaire. To determine the levels of SChE, a reactive paper finger blood test was implemented. Pearson's Chi-square and Pearson's correlation tests were used to analyze the relationship between the farmers' health status and their pesticide handling practices. The results revealed that almost 48.08% of the respondents were at a high risk level and almost all the respondents had abnormal levels of SChE, which were at risk and unsafe with 36.78% and 45.19% of respondents, respectively. Therefore, the recommendation is to encourage farmers to reduce pesticide usage and stricter surveillance of pesticide usage should be implemented, especially SChE levels screening test to raise awareness of the pesticide usage.

Keywords**:** *agriculture; farmer; health risk; pesticides; pesticide exposure; serum cholinesterase level.*

1. Introduction

Agriculture is one of the most important sectors in the economy (Lee, 2021). Approximately 46.54% of the total area was used for agriculture in the year 2019 (Office of Agricultural Economics, 2021). Thailand imports large amounts of pesticides. The statistics from the Bureau of Plant and Agricultural Materials Control (2020) showed that imports of pesticides of 160,824 tons, 170,932 tons, 131,308 tons and 98,449 tons in the years 2017, 2018, 2019 and 2020, respectively (Bureau of Plant and Agricultural Materials Control, Thailand, 2020). Thai farmers are permitted to use pesticides freely, however, there are serious health effects on users and the environment when they are used inappropriately (Sapbamrer, & Nata, 2014). The morbidity rates caused by the use of pesticides were about 12.95, 11.70 and 11.98 per 100,000 persons in the years 2018, 2019 and 2020, respectively (Division of Occupational and Environmental Diseases, Thailand, 2019; Division of Occupational and Environmental Diseases, Thailand, 2020). Moreover, Lampang province was ranked second in the morbidity rate caused by pesticides of 28.93 per

100,000 persons in 2018 (Division of Occupational and Environmental Diseases, Thailand, 2018).

Lampang province is in a region of high mountain plains and lowlands where there is an old sediment plain with moderately fertile soil along the banks of the Wang River which flows through the central part of the province. It is an agricultural area all year round with 1,078,122 rai of agricultural land. The most cultivated area is Muang district of approximately 173,652 rai. Farming is the main occupation that generates incomes for the population in Lampang province. The farmers are mainly smallholder farmers. In addition, agricultural products are transported inside the country and exported outside the country (Lampang Provincial Agricultural Extension Office, 2020).

In 2014, Lampang Provincial Public Health Office checked the cholinesterase level in the blood of farmers in areas of agricultural cultivation where it was found that farmers were at high risk of exposure to pesticide at 82% (Department of Disease Control, 2016). In Lampang province, the previous study mentioned that the herbicides were mostly used in the pineapple farming (98.16%) and the insecticides were used about 33.72% (Jamsil, 2012).

Previous studies in this area concerning pesticide use and the health effects on farmers found that the farmers who were exposed to pesticides, have experienced harmful side effects, such as dizziness, nausea, and vomiting. (Riwthong, Schreinemachersm, Grovermann, & Berger, 2017; Kangkhetkron, & Juntarawijit, 2021). These health effects could be due to the poor handling and use of pesticides, such as leaking spraying tanks, smoking while working and eating food and drinking alcohol in the agricultural areas (Laor et al., 2019). In addition, a marker to indicate exposures to organophosphates and carbamate is acetylcholinesterase activity. The previous study found that Thai farmers, a group in which associations were observed between acetylcholinesterase activity levels and health outcomes by using this biomarker. Its advantage is quick processing with basic laboratory equipment, which makes field-based pesticide exposure screening more feasible (Nambunmee, Kawiya, Neitzel, & Seeprasert, 2021).

Therefore, this study aimed to investigate farmers' handling practicing of pesticides of and the symptoms they experienced after being exposed to pesticides, in order to evaluate the health risks of exposure and also to measure the cholinesterase levels in the blood of farmers and study the relationship between their use of pesticides and their health.

2. Objectives

The objectives of this study are 1) to investigate the pesticide practices of farmers and their symptoms after exposure to pesticides; 2) to evaluate the health risks of exposure to pesticides; 3) to measure the cholinesterase levels in the blood of farmers; 4) to study the relationship between demographic characteristics and handling of pesticides with health risk levels and the health statuses of respondents; and 5) to study the correlation comparing demographic characteristics with pesticide handling practices and health risk levels and the health status of respondents

3. Methods and data and descriptive

This study was a cross-sectional study, which was conducted from to June 2019 to August 2020 in the Muang district of Lampang province. The sample size was calculated following the work of Krejcie, & Morgan (1970) with the proportion of population at 95 % CI plus 10 % for errors (Krejcie, & Morgan, 1970). A total of 416 respondents was recruited by purposive sampling. Purposive sampling is one that is nominated based on characteristics of a population and the purpose of the study. The samples included the representatives of a farmer's family aged 18 year-old and above who were working in agriculture and were exposed to pesticides for at least 1 year. The exclusive criteria were respondents who considered any confounding variables, including diabetes, liver disease, and kidney disease. Data were collected from face-to-face interviews using a structured questionnaire at a Health Promoting Hospital, which was near where the participants lived. The respondents were allowed 30 minutes to complete the questionnaire. Data were collected on random days without consideration to whether using pesticides was done or not during the data collection periods.

3.1 Methods

3.1.1 Questionnaires

3.1.1.1 Characteristics of the respondents

The demographic characteristics included gender, age, status, education level, family income, main occupation, and type of cultivation.

3.1.1.2 The farmers' use of pesticides

There were 20 questions, divided into 2 parts: Part 1 (the use of pesticides) consisted of 5 questions such as inquiring about the participants' pesticide use, duration, and frequency of use, purpose of use and the types of pesticides used. Part 2 related to the farmers' behavior while working. There were 15 questions with a Likert Scale from 1 to 3. The maximum score of 3 (always) and 1 (never) was for the negative questions (statements: 1-9) and vice versa for positive questions (statements: 10-15).

3.1.1.3 Symptoms after exposure to pesticides

The symptoms after exposure to pesticides, red/stinging eyes, tiredness, numbness, were divided into 4 groups of symptoms, including no symptoms, group of symptom 1, group of symptom 2, or group of symptom 3. Group of symptom 1 involved coughs, nose irritation, sore/ dry throat, shortness of breath, dizziness, headache, insomnia, skin irritation, skin rash, burning sensation heart palpitations, sweating, eye watering flow, dribbling or runny nose. Group of symptom 2 involved eye twitching, blurred vision, chest pains, vomiting, abdominal pain, diarrhea, muscle fatigue, muscle cramps, trembling hands, and staggering. Group of symptom 3 involved seizures and falling unconsciousness. The symptoms experienced after exposure to pesticides and the levels of health risks are shown in Table 1.

Table 1 The health risk levels

Symptom	Health risk level		
	15-24 scores	**25-30 scores**	**31-45 scores**
No symptom	Low	Moderate	Quite high
Group of symptom 1 (≥ 1 symptom)	Moderate	Quite high	High
Group of symptom 2 (≥ 1symptom)	Quite high	High	High
Group of symptom 3 (≥ 1symptom)	High	High	Very high

3.1.2 Validity of the questionnaire

The questionnaires were validated by 3 experts who were specialists in the fields of public health, environmental health, and occupational health. The item objective congruence (IOC) technique was applied to confirm and revise the questionnaires (Supparerkchaisakul, Mohan, & Fansler, 2017). A pilot-test of 30 people in a similar area was used to test the reliability of the questionnaire. Cronbach's alpha was used to determine the reliability which was calculated at 0.82

3.1.3 Screening test of cholinesterase levels in farmers' blood

The screening test for serum cholinesterase (SChE) levels in the farmers' blood of followed 4 steps: (i) finger-blood was drawn from the fingertip of the sample and three-fourths of the tube was filled with a heparin-coated capillary tube; (ii) the end of the tube without red mark was filled with plasticine to achieve a separation between the red blood cells and the serum; (iii) the capillary tube was broken at the junction between red blood cells and serum, then a drop of the serum was applied to a test paper (of reactive paper) and left for 7 minutes to allow the serum to react with the test paper. The sensitivity and specificity of the reactive papers were tested by comparison with the results of an examination by Bigg's laboratory method using a paired t-test, which showed that there was no statistically significant difference in the results between the two methods ($p<0.01$) at a confidence level of 99%. The predicted values for sensitivity, specificity and positivity were 89.89%, 95.65% and 94.59%, respectively; and (iv) screening for SChE levels was analyzed by observation of the change in color of the test paper (Division of Occupational and Environmental Diseases, 2015). However, the limitations of the SChE levels screening method were apparent in the changing colors on the reactive paper which might have led to errors. Therefore, we asked for the assistance of officers of the subdistrict Health Promotion Hospital who were trained to perform SChE levels screening tests and to interpret the results correctly. The quality of the SChE test paper was inspected before use as the color of the test paper should be yellow. If it changes to another color or becomes moist or swollen, it will not be of any use. Moreover, the expiration date of the SChE test paper was checked. The performance of the SChE test papers was monitored to verify their effectiveness by dropping lymphatic fluid onto the test paper. If the test paper immediately changed from yellow to green, it indicated that the test paper was still effective. The SChE test papers were always stored in a glass bottle or a colored plastic (PET) bottle in a cool and dry place or stored in the refrigerator at 4-8 ºC. In addition, this study excluded those samples which contained any substance that inhibits the enzyme acetylcholinesterase (Division of Occupational and Environmental Diseases, 2015). The results were divided into 4 levels by comparing the colors with a standard color sheet (Table 2).

Table 2 Health status indicator following the standard colors of the reactive paper according to the cholinesterase enzyme levels

Reactive paper	Cholinesterase enzyme levels (units/ml)	Health status
Yellow	≥100	Normal
Yellow-green	87.5-99.9	Safe
Green	75.0-87.4	Risk
Blue	<75.0	Unsafe

3.2 Data and descriptive statistics

The data were analyzed by the Statistical Package for Social Science (SPSS) version 22.0 with a statistical significance at p-value<0.05. Quantitative variables, including frequencies and percentages, were analyzed by descriptive statistics to report the demographic characteristics and the health risks of the samples. Pearson's Chi-Square and Pearson's correlation statistics were used to assess the association between the farmers' health status and/or the demographic characteristics of handling pesticides and also the health risk levels. The most commonly used statistical test to evaluate independence when using a bivariate table is Pearson's Chi-Square test. This test was evaluated the relationship exists between the two variables by comparing the observed pattern of responses in the cells to the pattern that would be expected if the variables were truly independent of each other. It was observed from the Chi-Square that the distribution of cell counts was significantly different from the expected cell counts from calculating the Chi-Square statistics and comparing it with a critical value (p-value) (Turhan, 2020). Guilford's interpretation of the magnitude of significant correlation coefficients (r) shows the following: less than 0.19 (slight), 0.20-0.39 (low), 0.40-0.69 (moderate), 0.70-0.89 (high) and 0.90-1.00 (very high) (Aswegen, & Engelbrecht, 2009).

3.3 Ethical approval

This study was permitted by the Human Research Ethics Committee of Thammasat University (Science) (No.208/2561). The participants in this study were volunteers. Anonymity was preserved to protect the subjects' identities and confidential information.

4. Results

4.1 Demographic characteristics of the samples

The demographic characteristics of the samples are shown in Table 3. The respondents were 416 farmers including males (48.92%) and females (51.08%). Most of the respondents were aged between 51-60 years (45.10%) and more than 60 years (34.07%) of which 79.50% were married. Most of them (67.15%) had a primary school qualification. Most of them (80.49%) had an average family income of approximately less than 10,000 Baht per month. Approximately 90.23% of the respondents were self-employed farmers. The main crop was from paddy farming (61.14%). About 28 -55 % of the farmers had mixed, sprayed, and used or sprayed pesticides once or twice a week. Most of them (30.09%) had worked in the agricultural sector for the previous 5-10 years. The purpose of using pesticides was to get rid of insects (50.13%) and weeds (71.43%). The most commonly used pesticides were paraquat dichloride (61.69%) and glyphosate isopropyl ammonium (38.31%).

Table 3 Demographic characteristics of the samples

Demographic Characteristics	**n**	**%**
Gender (n=415)		
Male	203	48.92
Female	212	51.08
Age (years) (n=408)		
18-30	8	1.96
31-40	14	3.43
41-50	63	15.44
51-60	184	45.10
More than 60	139	34.07
Marital status (n=400)		
Single	32	8.00
Married	318	79.50
widowed/divorced/separated	50	12.50
Education level (n=411)		
No schooling	26	6.33
Primary school	276	67.15
Junior high school	44	10.71
High school/vocational certificate	42	10.22
Diploma/High vocational certificate	11	2.68
Bachelor's degree	12	2.92
Average family income per month (n=410)		
Less than 10,000 baht	330	80.49
10,000-14,999 baht	58	14.15
15,000-19,999 baht	9	2.20
More than 20,000 baht	13	3.17
Main agricultural occupation (n=399)		
Farmer (self-employed)	360	90.23
Farmer (wage earner)	23	5.76
Contractors for pesticides spraying	3	0.75
Other employment related to agriculture (such as harvesting rice, planting vegetables, cultivating mushrooms, tying onions and garlic, tying vegetables for sale, mowing, weeding, general hire)	13	3.26
Main cultivated crops (n=386)		
Crop farm	88	22.80
Paddy farm	236	61.14
Gardening	62	16.06
Pesticides usage		
Pesticide mixer (n=375)		
Pesticide mixer	105	28.00
Never	270	72.00
Pesticide sprayer (n=400)		
Self-sprayer	177	44.25
Contractors for pesticides spraying	223	55.75
Being in the area where there was spraying or being exposed to sprayed fruits and vegetables during harvesting, bundling, wrapping, and packing (n=400)		
In contact with pesticides during spraying	221	55.25
Never	179	44.75

Demographic Characteristics	**n**	**%**
Duration of pesticide usage (n=319)		
Less than 1 year	4	1.25
1-3 years	51	15.99
3-5 years	38	11.91
5-10 years	96	30.09
11-20 years	81	25.39
21-30 years	34	10.66
More than 30 years	15	4.70
Average weekly pesticides exposure (n=273)		
1-2 days/week	177	64.84
3-4 days/week	24	8.79
5-6 days/week	40	14.65
Every day	32	11.72
Purpose of using pesticides in agriculture		
To get rid of insects (n=371)		
Yes	186	50.13
No	185	49.87
To get rid of weeds (n=385)		
Yes	275	71.43
No	110	28.57
Commonly used pesticides (n=261)		
Paraquat dichloride (Herbicides)	161	61.69
Glyphosate isopropyl ammonium (Herbicides)	100	38.31

4.2 Use of pesticides by the respondents in agricultural areas

Table 4 shows the results of the use of pesticides obtained from the questionnaire. About 16.8% and 27.5% of the respondents always used insecticides and herbicides, respectively. Approximately 10.2 % of the respondents handled pesticides incorrectly, for example, by using leaking pesticide collection tanks, by exposure to pesticides while working, wearing clothes soaked with pesticides, by having an unusual symptom after using pesticides, by smoking during work, eating food, or drinking water or alcohol while working in agricultural areas. While most of the respondents (91.8 %) handled pesticides following the information on the pesticide labels, wearing protective equipment (gloves and boots) during pesticide usage, washing hands before eating and drinking, changing clothes immediately after using chemical pesticides and taking a bath soon after working.

4.3 Symptoms after exposure to chemical pesticides in 2019

Table 5 shows the farmers' symptoms after exposure to pesticides. It was found that 68.3% (284 persons) had no symptoms associated with pesticides and 23.6% (98 persons) had symptoms after pesticide exposure in the previous month. After being exposed to pesticides, the farmers' symptoms were coughing, red/stinging eyes and blurred vision, with 30.6%, 26.5%, and 26.5%, respectively. While the symptoms of seizures and loss of consciousness were 1.0% and 1.0% of the respondents, respectively. After checking the health of the respondents using SChE levels of farmers' blood, the results showed that 36.78% and 45.19% of the respondents were at risk or unsafe, respectively.

Table 4 Pesticide handling practices of the participants in agricultural areas

Pesticides practicing	Frequency, n (%)		
	Never	Sometimes	Always
1. Using insecticides in agricultural areas	136 (36.7)	165 (39.7)	70 (16.8)
2. Using herbicides in agricultural areas	102 (25.8)	185 (46.7)	109 (27.5)
3. Using leaking pesticide collection tanks during spraying	291 (73.7)	86 (21.8)	18 (4.6)
4. Having been exposed to pesticides while working	167 (42.5)	196 (49.9)	30 (7.6)
5. Wearing clothes soaked in pesticides while working	248 (62.8)	123 (31.1)	24 (6.1)
6. Having any unusual symptoms after using pesticides	317 (80.1)	68 (17.2)	11 (2.8)
7. Smoking during work	365 (93.4)	17 (4.3)	9 (2.3)
8. Eating food or drinking water while work in the work area	304 (76.6)	58 (14.6)	35 (8.8)
9. Drinking alcohol while work in the work area	355 (89.9)	35 (8.9)	5 (1.3)
10. Reading information on pesticide labels	72 (18.4)	41 (10.5)	278 (71.1)
11. Wearing gloves while handling pesticides	38 (9.6)	43 (10.9)	314 (79.5)
12. Wearing boots while handling pesticides	24 (6.1)	16 (4.0)	356 (89.9)
13. Washing hands before eating and drinking	14 (3.6)	10 (2.5)	370 (93.9)
14. Changing clothes immediately after using pesticides	33 (8.4)	34 (8.7)	325 (82.9)
15. Taking a bath immediately after working	28 (7.2)	16 (4.1)	346 (88.7)

Table 5 Symptoms after exposure to chemical pesticides in 2019

Group of symptoms					
Group 1	**n (%)**	**Group 2**	**n (%)**	**Group 3**	**n (%)**
Coughing	30 (30.6)	Eye twitch	4(4.1)	Seizures	1 (1.0)
Nose irritation	19 (19.4)	Blurred vision	26(26.5)	Unconsciousness	1 (1.0)
Sore throat/dry throat	12 (12.2)	Chest pain	19(19.4)		
Shortness of breath	13 (13.3)	Vomiting	7(7.1)		
Dizziness	25 (25.5)	Abdominal pain	5 (5.1)		
Headache	14(14.3)	Diarrhea	2(2.0)		
Insomnia	6(6.1)	Muscle fatigue	5(5.1)		
Skin irritation	22 (22.5)	Muscle cramps	17(17.4)		
Skin rash	21(21.4)	Trembling hands	12(12.2)		
Burning pain	14(14.3)	Stagger	6 (6.1)		
red/stinging eyes	26 (26.5)				
Tiredness	12 (12.2)				
Numbness	13 (13.3)				
Heart palpitations	0 (0.0)				
Sweating	11(11.2)				
Watering eyes	12(12.2)				
Dribbling	7(7.1)				
Runny nose	2(2.0)				

4.4 Health risk levels of handling pesticides practicing

The results of the health risk levels of handling pesticides practicing is shown in Table 6. The results revealed that 39.66 % of the respondents were at a moderate health risk level, however, almost 48.08% of the respondents were at a high risk level. 11.78 % of the respondents were at a low risk level.

Table 6 Respondents' health risk levels of handling pesticides

Health risk levels of handling pesticides n (%)				
Low	**Moderate**	**Quite high risk**	**High risk**	**Very high risk**
49 (11.78)	165 (39.66)	117 (28.13)	83 (19.95)	2 (0.48)

4.5 Health statuses of respondents (SChE levels of farmers' blood)

The results of health statuses of respondents (SChE levels of farmers' blood) is shown in Table 7. The results of the health of the respondents were analyzed from the SChE levels in the blood of the respondents. It was found that 36.78% and 45.19% of the respondents were at the risk and unsafe levels, respectively.

Table 7 Respondents' health statuses (SChE levels of farmers' blood)

Cholinesterase enzyme levels * n (%)			
≥100 units/ml	**87.5-99.9 units/ml**	**75.0-87.4 units/ml**	**<75.0 units/ml**
19 (4.57)	56 (13.46)	153 (36.78)	188 (45.19)

*Cholinesterase enzyme levels; ≥100 units/ml indicated that normal status; 87.5-99.9 units/ml indicated that safe status; 75.0-87.4 units/ml indicated that risk status; <75.0 units/ml indicated that unsafe status

4.6 Pearson's chi-square test of demographic characteristics and handling of pesticides with health risk levels and the health statuses of respondents

Pearson's chi-square test was used to analyze the correlation between demographic characteristics and handling of pesticides with health risk levels and the health statuses of respondents (Table 8). Marital status and education levels had a significant statistical relationship to the health levels (p-value=0.036, p-value=0.005), at p<0.05. In addition, handling insecticides in an agricultural area, using leaking pesticide collection tank while spraying and smoking while working had a significant statistical relationship to the respondents' health (p-value=0.014, p-value=0.018, p-value=0.027), at p<0.05. However, SChE levels of the farmers' blood did not correlate with the health risks of the respondents (p-value=0.986), at p<0.05.

Table 8 Results of Pearson's chi-square test comparing demographic characteristics with pesticide handling practices or health risk levels and the health statuses of the respondents

Variables	**Health statuses (SChE levels of farmers' blood)**	
	Chi-square	**p-value**
Demographic characteristics		
Marital status	13.503	0.036*
Education levels	32.863	0.005*
Pesticide handling practices		
Using insecticides in an agricultural area	15.976	0.014*
Using leaking pesticide collection tanks while spraying	15.362	0.018*
Smoking while working	14.277	0.027*
Health risk levels	5.594	0.986

*Significant at p-value <0.05

4.7 Pearson's correlation test between demographic characteristics and pesticide handling practices or health risk levels and the health statuses of respondents

After analyzing the results, the relationship between the pesticide handling practices and health status was found. As shown in Table 9, having been exposed to pesticides while working, wearing clothes soaked in pesticides while working and smoking while working had a significant statistical relationship to health (SChE levels of farmers' blood) (r=0.111, p-value=0.029; r=0.149, p-value=0.003; r=0.103, p-value=0.043 respectively), at p-value<0.05, which indicated a slightly positive correlation. Whereas wearing boots while handling pesticides showed a significant statistical relationship to health statuses (SChE levels of farmers' blood) (r=-0.109, p-value=0.032), at p-value<0.05, which indicated a slightly negative correlation.

Table 9 Pearson's correlation test comparing demographic characteristics with pesticide handling practices and health risk levels and the health status of respondents

Variables	Health statuses (SChE levels of farmers' blood)		
	r	p-value	Correlation level
Pesticide handling practices			
Having been exposed to pesticides while working	0.111	0.029*	Slightly positive
Wearing clothes soaked in pesticides while working	0.149	0.003*	Slightly positive
Smoking while working	0.103	0.043*	Slightly positive
Wearing boots while handling pesticides	-0.109	0.032*	Slightly negative

*Significant at p-value <0.05

5. Discussion

This study included the ages of the respondents, which is similar to previous studies (Santaweesuk, Boonyakawee, & Siriwong, 2020; Duangchinda, Anurugsa, & Hungspreug, 2014). The ages showed that the farmers had been farming for a long time. Most of them had a primary school education, which is the same as the previous study of Santaweesuk and Siriwong (2021), Santaweesuk et al. (2020), and Boonyakawee, Taneepanichskul, and Chapman (2013). This previous study showed that a limited education may result in a lack of knowledge concerning how to handle pesticides safely (Duangchinda et al., 2014). Most of the respondents (80.49%) had an average family income of less than 10,000 Baht/month which is similar to a previous study (Wongta et al., 2018). Therefore, the farmers focused on high productivity by using pesticides which were easy to find, convenient and labor saving. Additionally, because of the limited income of the respondents, it affected their personal protective equipment (PPE). The most commonly used pesticides were paraquat dichloride and glyphosate-isopropylammonium, which is also the same as in the previous study. These two herbicides were the most intensively used herbicides in Thailand, with approximately 13 and 27 million kilograms in 2013, respectively (Tawatsin, 2015). However, farmers also use insecticides, sometimes when insects interrupt their crops for a short period. Therefore, insecticides were fewer used than herbicides.

The results of this study which found that leaking pesticide tanks were sometimes or always used (26.4%) are similar to previous reports (Laor et al., 2019; Duangchinda et al., 2014). However, while working, the respondents had also been exposed to pesticides when their clothes were occasionally or always soaked with 57.5% and 37.2%, respectively, which indicated that these respondents were subject to health risks. Approximately 80-93% of the respondents had never smoked, eaten food, or drunk water or alcohol while working, which was more frequent than in previous studies (Suk-ueng & Panaadisai, 2021; Laor et al., 2019). About 71% of respondents had always read the information on the label, which was more frequent than that of previous studies (Suk-ueng & Panaadisai, 2021; Kangkhetkron, & Juntarawijit, 2021). Furthermore, about 80-90% of the respondents had worn gloves and boots, which was a higher amount than that of the previous study (Laor et al., 2019). With regard to best practices of washing hands before eating and drinking, changing clothes immediately after using pesticides and taking a bath immediately after working, these findings were 94%, 83% and 89%, respectively. These results indicate that their practices could have reduced the amounts of pesticides absorbed into their bodies (Rother, 2018).

In terms of health symptoms, this study found that the major symptoms among respondents were coughing (30.6%), red/stinging eyes stinging (26.5%) and blurred vision (26.5%). The results of this study were similar to those of a previous study (Kongtip et al., 2018). But the symptoms experienced by the farmers were different from the reports of Kongtip et al. (2018), because the farmers' most common symptoms included coughing (36.0%), eye irritation/red eyes (29.0%) and blurred vision (45.0%) (Kongtip et al., 2018). This study also differed from reports by rice, sugarcane, and cassava farmers in Nakhon Sawan province, Thailand, who had irritated eyes (40.3%) (Kangkhetkron, & Juntarawijit, 2021).

The prevalence of abnormal serum cholinesterase (SChE) levels in the respondents was 81.97% (risk 36.78% and 45.19%), which is higher than that of previous studies (Santaweesuk, Boonyakawee, & Siriwong, 2020; Laor et al., 2019). Similarly, in cases where there was long-term exposure to pesticides, it affected the SChE levels in Thai chili-farm workers. This result showed that the SChE levels indicate chronic low-dose exposure. The prevalence of abnormal SChE levels was considerably higher than that among a normal group. The prevalence of abnormal SChE levels was also higher than that in rice farmers who followed proper handling practices (Kachaiyaphum, Howteerakul, Sujirarat, Siri, & Suwannapong, 2010).

Our findings revealed that some of the farmers had handled insecticides inappropriately, had used leaking pesticide collection tanks, been exposed to pesticides while working, and pesticides from soaking clothes, smoked while working, ate food, or drank water or alcohol while working in agricultural areas. Our results were similar to those of a previous study by Laor et al., (2019). Moreover, this study found that the farmers who smoked while working in agricultural areas had a significant relationship to their health. Laor et al., (2019) found that the practice of not smoking at work in agriculture was associated with health risk. The reason for this was that if the farmers smoked while working, it prevented pesticides from entering their body through the nose and mouth. Thus, the SChE levels did not correlate with health risk levels, which was similar to the results of Nilpradit (2013). Most of the farmers have handled the pesticides correctly, which meant that they were well aware of the risks from pesticides.

These findings showed that (1) Although most farmers had never been directly exposed to pesticides, or worn clothes soaked with pesticides or smoked while working, they still had have abnormal levels of the SChE in their blood; and (2) Although most farmers had always worn boots while handling pesticides it was still found that they had abnormal levels of SChE levels in their blood. These findings indicate that although the farmers handled pesticides appropriately, the effects of working with pesticides remained severe and harmful, which is similar to previous reports (Waseeweerasi, Chanthamolee, Wisetkaew, & Srilatham, 2020; Wongsakoonkan, 2016). However, it should be noted that this study had limitations, since it only assessed abnormal levels of SChE in farmers and their pesticide handling practices. No other potential variables were investigated.

The practical implement policies about the SChE levels screening test should be divided according to level of risk as follows; (1) if the results of SChE levels' farmers are normal or safe level, the farmers should be tested their blood one a year and keep healthy according healthcare principle, and (2) if the results of SChE levels' farmers are risk or unsafe level, the farmers should be followed up once a month until the test results are normal or safe level. Furthermore, public health officers should recommend the group of farmers should stop being exposed to pesticides by changing their jobs and return to their work again when their blood test results are at a normal or safe level.

From this study it was found that most of the farmers had the handled pesticides correctly following all the appropriate procedures. However, it was found that there were also many cases of inappropriate handling such as using leaking pesticide collection tanks while spraying and smoking while working. Therefore, stricter pesticide usage measures should be taken due to long-term exposure to pesticides, even if this is only a relatively small amount. Exposure to pesticides can adversely affect the brain. Also, when farmers become ill through exposure to pesticides, they suffer from a loss of time and income. Hence, the recommendation of this study is to encourage farmers to reduce the use of pesticides and use biological agents instead and prevention of the danger from the use of pesticides must be monitored, especially screening by using reactive-paper finger blood test to raise awareness of the possible adverse health effects.

6. Conclusion

The results of this study showed that 68.3% had no symptoms associated with pesticides and 35% of the respondents had symptoms such as coughing, red eyes or irritation and blurred vision, with 30.6%, 26.5%. The results revealed that 39.66 % of the respondents were at a moderate health risk level, however, almost 48.08% of the respondents were at a high risk level. After checking the health of the respondents using SChE levels in farmers' blood, the results showed almost all the respondents had abnormal levels of SChE. The SChE levels in farmers' blood indicate that they were at risk and unsafe with 36.78% and 45.19% of respondents, respectively.

It was found that most of the farmers handled the pesticides correctly and followed the appropriate practices. However, it was found that there was also inappropriate handling of pesticides in many cases, such as using leaking pesticide collection tanks while spraying and smoking while working. Although most farmers followed appropriate handling practices of pesticides, it was found that farmers still have abnormal levels of SChE in their blood, because the effects of working with pesticides can still be severe and harmful to farmers' health. Therefore, the recommendation of this study is to encourage farmers to reduce the use of pesticides and use biological agents instead and to prevent the danger from the use of pesticides must be monitored, especially screening by using reactive-paper finger blood test to raise awareness of the possible adverse health effects.

Future studies should focus on other potential variables towards handling pesticides such as the period of blood's farmers screening test performance during farming activity, farmers' knowledge and attitude of pesticides usage and the use of intervention programs that could sustainably reduce their health risks from pesticides and maintain normal SChE levels in their blood. These findings in a simplified form should be notified to farmers who work in a similar situation to the respondents in this study, especially in the northern regions of Thailand.

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