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Health risk and health status of farmers exposed to chemical pesticides used in agriculture

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Abstract

Pesticide exposure is one of the most serious health risks among farmers in Thailand. Unsafe and poor pesticide handling practices in agriculture denote a major hazard to human health. This research aimed to assess the health risks of farmers exposed to pesticides and the relationship between farmers' health risks and their pesticide handling practices. This study was conducted in Mae Chan district, Chiang Rai province, in northern Thailand, from July to September 2018. A purposive sample of 241 respondents constituted the study population. The health risk assessment data was collected using a structured questionnaire and blood test. Quantitative data were analyzed by descriptive statistics. Pearson's Correlation and Chi-square test were used to identify the relationship between variables. The results show that more than 50% of the respondents were over 50 years old. The most common pesticide-related symptoms were dizziness, coughs and headaches. Poor handling and use of pesticides such as leaking spraying tanks, smoking while working, and eating food and drinking alcohol in the work area were observed. The health of farmers needs to be surveyed because more than half of the respondents were at risk. Farmers' health risks are associated with their handling of pesticides. Moreover, the use of personal protective equipment should be recommended to farmers for their safety whenever there is a possibility of being exposed to chemical pesticides.

Keywords*: *agriculture, chemical pesticide, cholinesterase, farmer, health risks, health status, reactive paper

1. Introduction

Thailand is in the top five consumer countries of pesticides in the world with an approximate total consumption of 87 million kg/year (Pariona, 2017). Agricultural products are an important part of Thailand's economy. Increases in agricultural exports has resulted in a greater use and more demand for chemical pesticides which cause public health risks and environmental contamination (Panuwet et al., 2012). Between the years 2007 to 2013 the amount of chemical pesticides imported into Thailand increased by 62,000 tons. Herbicides were the largest proportion of imported pesticides followed by insecticides. Because of intensive use and exposure, chemical pesticide intoxication is one of the major public health problems in Thailand. Morbidity rates of 49,000-61,000 cases per year have been reported, which means 76.4-96.6 persons per 100,000 people of which most cases were farmers and farm workers (Tawatsin, Thavara, & Siriyasatien, 2015). Previous reports found that the prevalence of the erythrocyte cholinesterase and plasma cholinesterase enzymes in rice farmers which represents a risk level of 26% and 29%, respectively (Wilaiwan, Baokumkong, Siriwong, & Pidgunpai, 2015) and, the prevalence of the serum cholinesterase enzyme (SChE) in chili-farm workers was found to be 32% (Kachaiyaphum, Howteerakul, Sujirarat, Siri, & Suwannapong, 2010). In addition, 97-100% of Chinese kale, pakchoi and morning glory samples from local markets and supermarkets were found to exceed the maximum residue limit for the contamination of pesticides in about 9-12 types (Wanwimolruk, Phopin, Boonpangrak, & Prachayasittikul, 2016). A variety of chemical pesticides are used in Thailand. Organophosphates in an insecticide group such as chlorpyrifos, dichorofos, parathion methyl and profennofos, have been used abundantly in agriculture (Jaca & Dharman, 2003; Sematong, Zapuang, & Kitana, 2008), as well as carbamates such as methomyl and fenobucarb (Plianbangchang, Jetiyanon, & Wittaya-areekuk, 2008). These insecticides can inhibit the functions of the acetylcholinesterase enzyme in the nervous system (Milatovic, Gupta, & Aschner, 2006; Goldman, 2007; Ooraikul, Siriwong, Siripattanakol, Chotpantarat, & Robson, 2011). Moreover, a research study between 2009 and 2016 showed that agriculturist suffered from adverse health effects resulting from the use of organophosphates (Rivera, Siriwong, Taneepanichskull, Korkaew, & Robson, 2016). In addition, types of organophosphate insecticides such as chlorpyrifos and cypermethrin were detected in soil and vegetables in Phaya Mengrai district of Chiang Rai province. Chlorpyriphos was the most commonly found chemical substances (Department of Environmental Quality Promotion, 2017). The suitable period for plantations is during the raining season. Rice is an important economic crop for Chiang Rai province. In the year 2014, rice production was 503 kg/rai of the harvested area and off-season rice production was 940 kg/rai of the harvested area (Ministry of Industry, 2016).

Chiang Rai province has an area of 1,184,736 rai of rice and is the largest rice-growing area in the upper northern region of Thailand. In the near future, Chiang Rai province will increase its use of organic agriculture and the Mae Chan district will establish an organic farm. While, farmers in the northern part of Thailand have transformed their subsistence-based rice farm to be a commercial rice farm and high-value cash crops. According to monitoring market prices, diversifying sales channels and applying large quantities of chemical pesticides, the use of pesticides on subsistence-based farms of about 2.7 kg/ha is low compared to those of commercial rice farms (21.5 kg/ha). Under conditions of poor pesticide handling practices, the exposed farmers have experienced harmful side-effects such as dizziness, nausea and vomiting (Riwthong, Schreinemachersm, Grovermann, & Berger, 2015). In this study, the cholinesterase level in the blood of farmers who are exposed to insecticides when they mixing, spraying, and contacting pesticide was determined to screen and assess the health risks of the pesticide-exposed farmers and the relationships of farmer health risks and the practice of pesticides being utilized were investigated.

2. Objectives

To assess the health risks of farmers exposed to pesticides and their effects.

3. Materials and methods

This research was conducted from July to September 2018 in Mae Chan district of Chiang Rai province which is located in the north of Thailand. The number of respondent samples (n) of 241 samples was determined by using purposive sampling method. Purposive sampling is one that is nominated based on characteristics of a population and the purpose of the study. In this study, the inclusion criteria are the group of farmers who applied pesticides (mixing, spraying and contacting of pesticide) in the last three months in their agricultural fields was selected to be the respondents.

3.1 Ethic consideration

The experimental protocol no. REH 59131 was approved by the Ethics Review Committee for Research Involving Human Research Subjects.

3.2 Questionnaire

A questionnaire weighing scale and height taking scale was used in the instruments for gathering data. The questionnaire contained three different parts according to the type of data. The first part (part 1) consisted of detailed demographics information such as age, gender, education level, main occupation, duration of work in agriculture, types of plant and chemical pesticides practice in the last 3 months. The subsequent second part (part 2), using and practicing of pesticide information, contains in total 14 questions, were structured and close-ended were set in a Likert Scale with a maximum score of 3 (always) and 1 (never) for statement no.1-6 and vice versa for statement no.7-14. The third part (part 3) collected pesticide-related symptom information whereas covering 4 groups of health symptoms levels such as no symptom, mild, moderate and severe symptoms. Mild level symptoms are fatigue, cough, breathing problems, dizziness headache, skin irritation, dry skin, skin rash, skin ulcers, eyes irritation numbness, heart palpitation insomnia, stuffy nose, sore throat shortness of breath, perspiration, drooling and, tears flowing. Moderate level was blurred vision, chest pain, vomiting, abdominal pain, diarrhea, muscle fatigue, muscle cramps, tremors and staggering. Severe level symptom was unconsciousness and seizures. Moderate level symptom was blurred vision, chest pain, vomiting, abdominal pain, diarrhea, muscle fatigue, muscle cramps, tremors and, staggering. Severe level was unconsciousness and seizures. The screenings of health risk levels were concluded as shown in Table 1.

Table 1 Screenings of health risk levels

Symptom	Health risk level		
	14-20 scores	21-28 scores	29-42 scores
No symptom	Low	Moderate	Quite high
Mild level	Moderate	Quite high	High
Moderate level (>1 symptom)	Quite high	High	High
Severe level (>1 symptom)	High	High	Very high

The validity of the questionnaire was confirmed by 3 experts including the expert in the field of public health, occupational health and environmental health and its revision was done by using the item objective congruence (IOC) technique of Rovinelli and Hambleton (1977) cited in U-thaiwat, Supparerkchaisakul, Mohan, and Fansler (2017). The reliability of the questionnaire was tested by using a pilot-test of 50 people in a similar area. To determine the reliability of (part 2) using and practicing of pesticide information, the Cronbach's alpha of 0.789 was computed.

Data collection was as follows: 1) collected data by questionnaires related with the use of agricultural chemicals and farmers' behavior while using agricultural chemicals; 2) The location for data collection was a health promoting hospital, a place that participants are suitable for participation; 3) researchers and research assistants explained the questionnaires to each participant and 4) questionnaires were collected 5-10 minutes per person.

3.3 Blood testing

The finger-blood of the respondents was placed in a capillary tube and a serum was collected by the centrifugal method. To determine the health of the farmers, the cholinesterase levels in the serum were determined by using reactive-paper (cholinesterase reactive paper). The sensitivity, specificity, and positive predicted value of the reactive paper were 89.89%, 95.65%, and 94.59%, respectively, which was as statistically significant ($p<0.01$). These values were tested in a laboratory by the government pharmaceutical organization that created cholinesterase reactive paper. The color of the reactive-paper changed according to the cholinesterase level (Table 2). Serum cholinesterase (SChE) levels were divided into 2 groups: a "normal level" of SChE value was more than 87.5 units/ml and an "abnormal level" was less than 87.5 units/ml.

Table 2 Health status indicator according color of reactive-paper and cholinesterase level

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

3.4 Data analysis

Data obtained from the questionnaire were analyzed using SPSS version 20, 2014 (SPSS, Chicago, IL). Quantitative data were analyzed by the descriptive statistics; frequencies and percentages to describe the demographic characteristics and health status of samples. Factors relation with using and practicing of pesticide information were analyzed by using Pearson's Correlation and Chi-square test at 95% confidence level ($p<0.05$).

4. Results

4.1 Demographic characteristics of the respondents

The results from the questionnaire, as shown in Table 3, found that 65.6% of the respondents were male. More than half of the respondents were over 50 years and the average age of the respondents was 56 years. The education level of most of the respondents was primary school. About 90% of the farmers had their own agricultural land. There were 80% of the respondents who had worked in the agricultural sector for more than 10 years. The main crops produced were rice and corn. Approximately 55-65% of the respondents had prepared, sprayed, transferred and stored chemical pesticides once or twice a week since planting started.

Table 3 Demographic characteristics of respondents

Demographic Characteristics	*n*	%
Gender		
Male	158	65.6
Female	83	34.4
Age		
Less than 40 years old	9	3.7
40-50 years	50	20.7
51-60 years	104	43.2
61-70 years	72	29.9
More than 70 years	6	2.5
Education level		
No schooling	10	4.2
Primary school	208	86.3
Secondary school	22	9.1
Diploma	1	0.4
Main Occupation		
Farmer/ self-employed	221	91.7
Farmer/ wage earner	8	3.3
Chemical pesticide spraying worker	3	1.3
Others (contractors, merchants, officers)	9	3.7
Duration of agricultural working		
Less than 1 year	8	3.3
1-3 years	7	2.9
3-5 years	5	2.1
5-10 years	24	10
11-20 years	66	27.4
21-30 years	50	20.7
More than 30 years	81	33.6
Type of plant		
Eggplants	6	1.3
Rubber tree	40	8.4
Rice	192	40.5
Mangos	3	0.6
Pineapples	2	0.4
Corn	139	29.3
Cassava	17	3.6
Bananas	10	2.1
Homegrown vegetables	56	11.8
Flowers	4	0.9
Soybean	1	0.2
Grain crops	4	0.9
Use of chemical pesticides in last 3 months (time/week)		
(1) Preparation		
Never	70	29
1-2 times/week	145	60.2
3-4 times/week	19	7.9
More than 5 times/week	7	2.9
(2) Spraying		
Never	55	22.8
1-2 times/week	156	64.8
3-4 times/week	22	9.1
More than 5 times/week	8	3.3

(3) Transferring and storage		
Never	82	34
1-2 times/week	132	54.8
3-4 times/week	20	8.3
More than 5 times/week	7	2.9
(4) In proximity to areas of chemical pesticide use		
Never	62	25.7
1-2 times/week	154	63.9
3-4 times/week	14	5.8
More than 5 times/week	11	4.6

4.2 Using and practicing of pesticides of the respondents in agricultural fields

The results of using and practicing of pesticides obtained from the questionnaire are shown in Table 4. The respondents of about 30% always used the insecticides and herbicides in their farm, whereas only about 19% of them had never used those pesticides. Poor handling and practicing of the pesticides such as usage of leaked pesticides spraying tank, smoking during work and eating food and drinking alcohol in the workplace area were observed, which were about 7% of the respondents. While about 77% of the respondents utilized good handling and practical use of the pesticides. In addition, almost 80% had the good practices of using pesticides such as reading chemical pesticide labels, wearing gloves and boots, changing clothes and taking a bath after using chemical pesticides. Nevertheless, 12% of them always utilized poor handling and practical use of the pesticides.

Table 4 Using and practicing of pesticide of the respondents in agricultural field

Items	Frequency, *n* (%)		
	Never	Sometimes	Always
(1) Using insecticides in agriculture	38 (15.8)	134 (55.6)	69 (28.6)
(2) Using herbicides in agriculture	53 (22.0)	110 (45.6)	78 (32.4)
(3) Using pesticides for spraying from leaking tanks	182 (75.5)	33 (13.7)	26 (10.8)
(4) Smoking at work	205 (85.1)	24 (10.0)	12 (5.0)
(5) Eating or drinking in the work area	158 (65.6)	62 (25.7)	21 (8.7)
(6) Drinking alcohol in the work area	201 (83.4)	30 (12.4)	10 (4.1)
(7) Reading information on labels of chemical pesticides	17 (7.1)	42 (17.4)	182 (75.5)
(8) Wearing gloves while using chemical pesticides	47 (19.5)	33 (13.7)	161 (66.8)
(9) Wearing boots while using chemical pesticides	38 (15.8)	17 (7.1)	186 (77.2)
(10) Taking a bath immediately after clothes contaminated by chemical pesticides	46 (19.1)	16 (6.6)	179 (74.3)
(11) Washing hands before eating and drinking	11 (4.6)	6 (2.5)	224 (92.9)
(12) Washing vegetables and fruits before eating	4 (1.7)	3 (1.2)	234 (97.1)
(13) Changing clothes immediately after using chemical pesticides	32 (13.3)	19 (7.9)	190 (78.8)
(14) Taking a bath immediately after working	35 (14.5)	7 (2.9)	199 (82.6)

4.3 Group of symptoms after exposing chemical pesticides

The information about pesticide-related symptoms obtained from the questionnaire found that 70.5% of the respondents (170 persons) had no symptoms related to the pesticides and followed by 29.5 % (71 persons) had symptoms after being exposed to chemical pesticides. The health risk levels of the respondents, who occasionally had symptoms after being exposed to chemical pesticides in the year 2017, are reported in Table 5. The most common symptoms after being exposed to chemical pesticides were dizziness, coughing, headaches and eye irritation. While the symptoms of vomiting and blurred vision were found at 15.5% and 12.7% among the respondents, respectively. Whereas, 2.8% of the respondents had an unconscious symptom.

Table 5 Group of symptoms after exposing chemical pesticides in year 2017

Group of symptoms					
Mild level	*n* (%)	Moderate level	*n* (%)	Severe level	*n* (%)
Fatigue	16 (22.5)	Blurred vision	9 (12.7)	Unconscious	2 (2.8)
Cough	20 (28.2)	Chest pain	4 (5.6)		
Breathing problems	8 (11.3)	Vomiting	11 (15.5)		
Dizziness	32 (45.1)	Abdominal pain	4 (5.6)		
Headache	18 (25.4)	Diarrhea	4 (5.6)		
Skin irritation/ dry skin	11 (15.5)	Muscle fatigue	5 (7.0)		
Skin rash/ skin ulcers	7 (9.9)	Muscle cramps	6 (8.5)		
Eyes irritation	16 (22.5)	Tremor	2 (2.8)		
Numbness	3 (4.2)	Stagger	1 (1.4)		
Heart palpitation	6 (8.5)				
Insomnia	6 (8.5)				
Stuffy nose	15 (21.1)				
Sore throat	10 (14.1)				
Shortness of breath	5 (7.0)				
Perspire	2 (2.8)				
Tears flow	5 (7.0)				

4.4 Health risk and health statuses of respondents

To evaluate the level of health risks from the use of chemical pesticides, the results obtained from questionnaire (part 2) on the use of pesticide information and (part 3) on information related to the symptoms resulting from pesticide use obtained from the questionnaire were analyzed and they are shown in Figure 1. It was found that almost 80% of the respondents were at the low or moderate health risk levels, with only 2% of the respondents at the high health risk level. Whereas, 44.8% of the respondents were at the low risk level, followed by 33.6% at the quite risk level and 19.5% at a moderate risk level, respectively. Furthermore, 2.1 % of the respondents were at the high risk level.

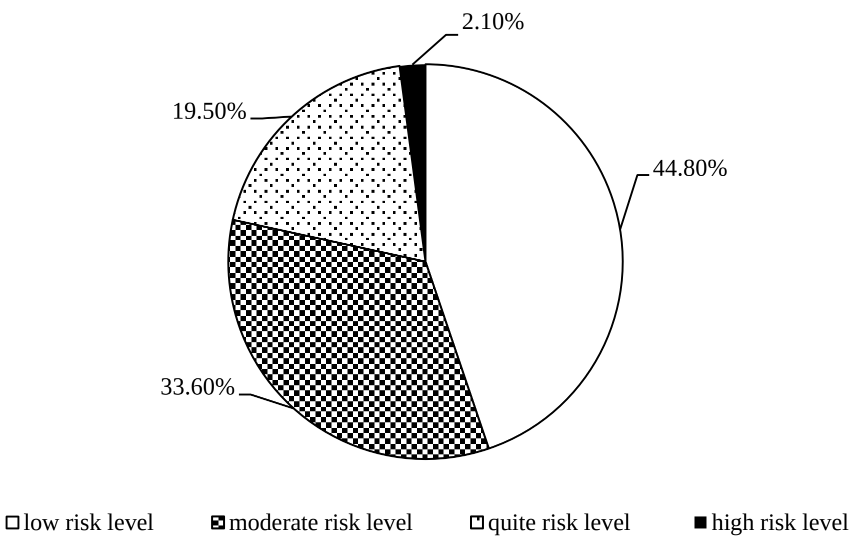

Figure 1 Health risk levels of chemical pesticide practicing

To determine the health of the farmers and agricultural workers, the results of the cholinesterase levels in the blood of the respondents were analyzed and they are shown in Figure 2. It was found that 34% and 26% of the respondents were at risk and in unsafe conditions, respectively.

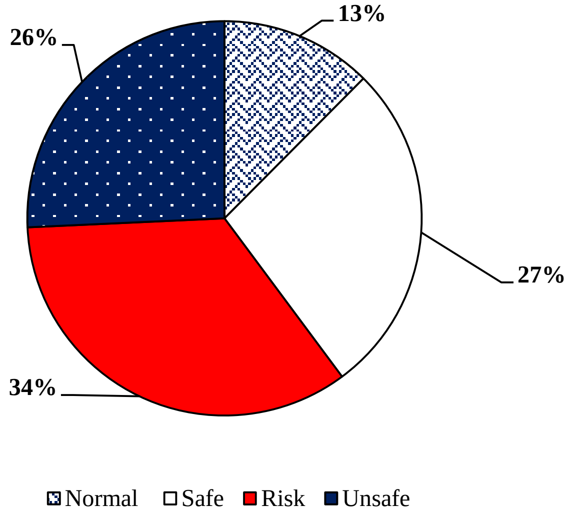

Figure 2 Health statuses of respondents

4.5 Correlation between "health risk levels" with "practicing of pesticides"

Pearson's r correlation test was used to find out the relationship between the levels of health risks and the use of pesticides in agriculture. As shown in Table 4, wearing boots while using chemical pesticides has a significant statistical relationship to the level of health risks (r=0.158, p=0.014), at p<0.05, which indicates a very weak positive correlation. Whereas, using such items as leaking tanks for the spraying of pesticides, eating or drinking water while working, drinking alcohol while working, changing clothes immediately after spraying chemical pesticides, and taking a bath immediately after working, had a significant statistical relationship to the levels of health risk (r=0.287, p=0.000; r=0.194, p=0.002; r=0.198, p=0.002; r=0.240, p=0.000 and r=0.252, p=0.000, respectively), at p<0.01, which indicate a weak positive correlation. In addition, reading the information about chemical pesticides on labels and washing hands before eating and drinking water had a significant statistical relationship to the levels of health risks (r=- 0.152, p=0.018 and r=- 0.136, p=0.035, respectively) at p<0.05, which indicated a very weak negative correlation.

5. Discussion

This research indicates that the respondents had used chemical pesticides in agriculture. It also found that insecticides were used more than 80% on the respondents' farms. Leaking tanks for spraying pesticides were used nearly 20% on the respondents' farms, which is similar to the reports of Duangchinda, Anuragsa, and Hungspreug (2014). They found that the use of faulty equipment and improper maintenance of spraying equipment were risk factors. About 85% of the respondents had never smoked at work and nearly 79% of the respondents had changed their clothes immediately after spraying, which corresponded to the results of Nordin et al. (2002). In addition, about 65% of the respondents had never eaten or drank at work, which was less than in a previous study (Kachaiyaphum et al., 2010). About 75% of the respondents had read the information on labels about the use of chemical pesticides and the wearing of gloves while using chemical pesticides was more frequent than in a previous study (Kachaiyaphum et al., 2010). In addition, the improper use of personal protective equipment and PPE was related to pesticide exposure (Rivera et al., 2016). The taking a bath or washing contaminated clothes after using chemical pesticides and changing clothes immediately after using chemical pesticides reduced the amount of chemical pesticide absorption into the body (Rother, 2018).

Common symptoms including dizziness (45.1%), coughs (28.2%) and headaches (25.4%) were commonly found among the respondents. The results of this research are similar to those of previous studies (Kongtip et al., 2018; Tawatsin et al., 2015; Kachaiyaphum et al., 2010). While a previous study of the health effects on vegetable farmers in Laos, Cambodia, and Vietnam (Schreinemachers et al., 2017) revealed that common symptoms such as dizziness (33%) and headaches (40%) occurred after spraying with chemical pesticides. Therefore, it can be seen that the same symptoms are commonly found as a result of the use of chemical pesticides.

The health risk levels from the use of chemical pesticides were moderate to quite level, respectively. Due to the occupational illnesses of the farmers, the health risk levels are a cause for concern and should be carefully monitored. The prevalence of abnormal SChE levels was found to be about 60% (risk 34% and unsafe 26%), which was different from previous reports (Kachaiyaphum et al., 2010; Chomthaisong, Nathapindhu, & Settheetham, 2007) who found the prevalence of abnormal SChE levels was 32.0% (risk 20.9% and unsafe 11.1%), 66.2% (risk 45.1% and unsafe 21.1%), and 49.3%, respectively.

The practice of not smoking at work in the agriculture and changing clothes immediately after spraying are associated with health risks levels, a statistical significance was found that not changing clothes immediately after spraying chemical pesticides and not taking a bath immediately after working, positively correlated to the health risk levels. It makes sense to note that if the farmers do not change their clothes and do not take a bath immediately after spaying the pesticides, it would increase a chance to absorb the pesticide to their body. As a result it could increase the health risk levels. On the other hand, if the farmers change their clothes and showers immediately, it could reduce a chance to absorb the pesticides to their body. This result was similar to Nordin et al. (2002) which found that changing clothes are important safety practices for prevention of the acute symptoms because it significantly prevented the occurrence symptoms after pesticide spraying. The result was shown if the farmers do not read information of chemical pesticides; do not wash hands before eating and drinking water when using the chemical pesticides that contribute to the negative health effects. It means that the health risks from the use of chemical pesticides could be reduced by good practices. Further, these results support the previous study of Stamati, Maipas, Kotampasi, Stamatis, and Hens (2016) who reviewed the urgent need toward cleaner and safer agricultural practices. They also reported the negative effects on human health caused by agricultural practices and the use of chemicals.

6. Conclusion

There are several reasons why the health status of farmers is related to chemical use in the field. The results indicated that the respondents had moderate and quite health risk levels from the chemical pesticide use in their agricultural fields. One-third of the respondents had symptoms such as dizziness, coughing and headaches, after being exposing chemical pesticides. Almost all of the respondents were found to have abnormal SChE level. The health risk levels and practices of the pesticide were a significant statistical relationship ($p<0.05$). However, from the results of this study suggested that the farmers should have a good handling chemical pesticide, the proper personal protective equipment such as gloves, boots, and air respirators should be provided to reduce the health risks from chemical pesticide exposure and a cholinesterase screening test should be conducted. In addition, the related agencies such as local governances should provide knowledge on the following items: proper chemical use, following proper procedures or protocol, proper PPE use, and personal hygiene to farmers when being exposed to chemical pesticide.

The researchers recommend that further studies should be in finding a proper protocol guideline for a safer way for farmers risk to be exposed to chemical pesticides and let them be aware of the effects on health and how to avoid improper behavior when using chemical pesticides.

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