Universal Journal of Public Health 11(4): 480-486, 2023 http://www.hrpub.org
DOI: 10.13189/ujph.2023.110413

Comparative Study of Two Pesticide-Associated Health Risk Assessment Methods: Questionnaire and Blood Cholinesterase Level Examination

Laksanee Boonkhao[1,*], Pongsak Rattanachaikunsopon[2], Thitima Saenrueang[1], Warisil Baukeaw[3]

[1]College of Medicine and Public Health, Ubon Ratchathani University, Thailand
[2]Department of Biological Science, Ubon Ratchathani University, Thailand
[3]Nongtae Health Promoting Hospital, Ubon Ratchathani Province, Thailand

Received March 31, 2023; Revised July 19, 2023; Accepted August 15, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Laksanee Boonkhao, Pongsak Rattanachaikunsopon, Thitima Saenrueang, Warisil Baukeaw , "Comparative Study of Two Pesticide-Associated Health Risk Assessment Methods: Questionnaire and Blood Cholinesterase Level Examination," Universal Journal of Public Health, Vol. 11, No. 4, pp. 480 - 486, 2023. DOI: 10.13189/ujph.2023.110413.*

(b): *Laksanee Boonkhao, Pongsak Rattanachaikunsopon, Thitima Saenrueang, Warisil Baukeaw (2023). Comparative Study of Two Pesticide-Associated Health Risk Assessment Methods: Questionnaire and Blood Cholinesterase Level Examination. Universal Journal of Public Health, 11(4), 480 - 486. DOI: 10.13189/ujph.2023.110413.*

Copyright©2023 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract When employing the Pesticide Exposure Risk Assessment Form for Farmers (Nor Bor Kor. 1-56) under the guidelines of the Bureau of Occupational and Environmental Diseases in the Department of Disease Control, previous studies have found that the majority of farmers face low level of health risks from pesticides (organophosphate and carbamate) exposure. However, the opposite result was frequently observed when cholinesterase levels were examined in the farmers' blood. It is of interest to find out whether or not these two risk assessment methods are in agreement. This study aims to compare two pesticide-associated health risk assessment methods: the health risk assessment questionnaire (Model 1) and blood cholinesterase level examination (Model 2). The participants were 195 vegetable farmers from Khi Lek Subdistrict, Ubon Ratchathani Province, Thailand. By the questionnaire method, the risks of pesticide exposure among the farmers were assessed based on their acute symptoms. By the blood cholinesterase level test method, the risks were assessed and divided into four levels: normal, safe, at-risk, and unsafe. These data together with data on pesticide use behavior were then used to assess the health risks of the participants. The results obtained from Model 1 and Model 2 were compared using the Stuart-Maxwell test. The findings show that the results obtained from Model 1 and Model 2 were statistically different (p-value <0.001). Therefore, it is important to consider that evaluating farmers' health risks based entirely on a questionnaire may not be appropriate. Blood cholinesterase level tests should be taken into account.

Keywords Health Risk Assessment, Pesticide, Questionnaire, Cholinesterase

1. Introduction

Insecticides (organophosphate and carbamate) play an important role in increasing agricultural productivity by controlling insects. However, they are harmful to organisms that are not their intended targets. Cholinesterase breaks down or hydrolyzes the neurotransmitter acetylcholine found in the lining of the synaptic space [1]. As a result, acetylcholine accumulation is prevented by the presence of cholinesterase. Organophosphate and carbamate, which bind covalently to a serine residue in the enzyme active site, can inhibit acetylcholinesterase (AChE) [2]. This irreversible inactivation leads to an excess accumulation of acetylcholine in the central and peripheral nervous systems, resulting in cholinergic symptoms [3]. Cholinergic toxicity can be both muscarinic and nicotinic [4]. Muscle pain, increased salivation, lacrimation, weakness, fasciculation of the muscles, diarrhea, and blurred eyesight are among the symptoms found. Insecticides at high levels inhibit the motor neuron and the peripheral muscles after suppressing the brain's respiratory center. It causes death by respiratory paralysis [5-7].

Researchers or government representatives in Thailand have used the Pesticide Exposure Risk Assessment Form for Farmers (Nor Bor Kor. 1-56) to assess health risks associated with farmers' exposure to organophosphorus and carbamate pesticides [8].

This model was created by the Bureau of Occupational and Environmental Diseases in the Department of Disease Control under the Ministry of Public Health. By using this assessment form, the Bureau of Occupational and Environmental Diseases takes into account both the likelihood and severity of the risks. The likelihood was established by analyzing data obtained from the behavioral questionnaire. The likelihood scores of risks are categorized into three ranges: likelihood score of 1 (indicating behavior scores of 15 to 24), likelihood score of 2 (indicating behavior scores of 25 to 30), and likelihood score of 3 (indicating behavior scores of 31 to 45). The likelihood scores are then calculated using matrices with the risk's severity. The severity is determined using a questionnaire on acute abnormalities present one month after pesticide use or exposure. The symptom scores are divided into four levels: level 1 (asymptomatic), level 2 (symptomatic when symptoms are present in group 1), level 3 (symptomatic when symptoms are present in group 2), and level 4 (symptomatic when symptoms are present in group 3). The severity of more acute symptoms will be taken into consideration if farmers have multiple symptoms which are divided into different symptom groups. The findings of the Nor Bor Kor 1-56 assessment showed that the farmers in Ubon Ratchathani had relatively high to very high risks of pesticide exposure (19.80% in 2014, 30.88% in 2015, and 18.45% in 2016). The blood cholinesterase level test showed that 40.5% of the farmers were at at-risk and unsafe levels in 2015, while 38.58% were in 2016. In 2014, 2015, and 2016, it was reported that the rates of diseases caused by pesticide poisoning in farmers per 100,000 people were 21.18, 22.08, and 31.02, respectively [9].

There are 1,630 houses in Khi Lek Subdistrict, Ubon Ratchathani Province, Thailand. Most of the population work in agriculture. Farmers grow vegetables such as cabbage, shallots, radish, mint, and chili after the rice growing season. Villages 5, 8, 9, and 10 are the four villages where vegetables are farmed. The agriculture in all the four villages has made extensive use of pesticides, especially carbamate and organophosphate. A previous study using the Nor Bor Kor 1-56 form to assess the health risks of farmers from pesticide exposure in Khi Lek Subdistrict found that most farmers (81.67%) had a low level of health risks [10]. However, the farmers in those areas regularly use pesticides, and a research, which examined blood cholinesterase levels in the farmers' blood, showed a different result as it found that 51.18% of them had abnormally high and unsafe cholinesterase levels, while 48.03% were at the at-risk level [11]. Therefore, the researchers are interested in examining the differences between the outcomes of the Nor Bor Kor. 1-56 risk assessment form takes into account the severity of the acute symptoms and those of blood cholinesterase level tests. The researchers believe that blood cholinesterase level tests give a more accurate result than the questionnaires because the farmer could potentially be biased, forgetful, and have a desire to withhold information. This study aims to compare two pesticide-associated health risk assessment methods: the health risk assessment questionnaire (Model 1) and blood cholinesterase level examination (Model 2).

2. Materials and Methods

2.1. Population and Sample

The participants in this study include 608 vegetable farmers from villages 5, 8, 9and 10 in Khi Lek Subdistrict, Ubon Ratchathani Province. The sample size was determined using the following Eq.1 [12].

$$n = \frac{NZ^2_{\alpha/2}\, p(1-p)}{[e^2(N-1)] + [Z^2_{\alpha/2}\, p(1-p)]} \qquad (1)$$

$$n = \frac{[(608)\left(1.96^2\right)(0.80)(1\text{-}0.80)]}{[0.05^2(608-1) + (1.96^2)(0.80)(1\text{-}0.80)]} \qquad (2)$$

n=175.27

When

n = Sample size

N = Population

$Z_{\alpha/2}$= the coefficient under the standard normal curve at 95% confidence level, $Z_{(0.025)}$ = 1.96

p = Proportion estimates; 0.80 obtained from literature reviews [10]

e = Precision of estimate; 0.05

When the researchers conducted an accidental sampling in the four villages, 195 vegetable farmers agreed to fill out the questionnaire.

2.2. Research Tools

1. The questionnaire: the Pesticide Exposure Risk Assessment Form for Farmers, created by the Bureau of Occupational and Environmental Diseases in the Department of Disease Control, was utilized [8]. The questionnaire contains three sections:

   Part 1 contains general personal information such as gender, age, level of education, average monthly income, marital status, and congenital diseases.

   Part 2 contains information on pesticide use and behavior at work and consists of 15 items. The likelihood of pesticide exposure was calculated using the behavioral score (Table 2).

Part 3 contains information on acute diseases or symptoms caused by exposure to or use of pesticides. If farmers had various symptoms, the researchers would assess the worst symptom group. To estimate the severity of the health risks, the data in this section were analyzed. There are four levels of symptom severity: asymptomatic, mild symptoms, moderate symptoms, and severe symptoms (Table 1 & 2).

2. To determine blood cholinesterase levels, blood was sampled and run across reactive paper [13]. Blood cholinesterase activity was classified into four levels: normal, safe, at-risk, and unsafe. Data on these four levels of acetylcholinesterase were utilized to calculate the risks. It is a risk assessment model created by the researchers.

2.3. Research Tool Quality Assessment

The tools' quality was assessed using the following methods:

- The questionnaire had a number of closed-ended questions. An index of item objective congruence (IOC) between 0.67 and 1.00 was obtained after three experts verified the content validity.
- The reliability of the questionnaire was verified on farmers in Ban Non Bon, Bung Wai Subdistrict, Warin Chamrap District, Ubon Ratchathani. After calculating Cronbach's Alpha Coefficient, the questionnaire's confidence level was 0.72. For it to be considered acceptable, the alpha coefficient must be 0.70 or higher [14].

2.4. Data Analysis

1. The risk matrix was determined using the data from Parts 2 and 3 to categorize the health risks associated with pesticide exposure by considering the severity of the acute symptoms experienced by the farmers (Table 2) and the data from Parts 2 and 3 were used to categorize the health risks associated with pesticide exposure by determining blood cholinesterase in the farmers which are divided into 5 levels: low, moderate, relatively high, high, and very high (Table 3).
2. The Stuart-Maxwell test was used to compare the differences between the outcomes of the two risk assessments.

2.5. Ethics

The Human Research Ethics Committee of Ubon Ratchathani University approved this project on March 1, 2022, determining that it complies with the criteria for ethical conduct in human research (Code UBU-REC-18/2565).

Table 1. Lists of details of acute symptoms experienced one month after pesticide usage or exposure

Symptom Group	Symptom description		
Group 1	- cough - burning nose - sore throat, dry throat - shortness of breath - dizziness - headache - poor sleep	- itchy skin, dry skin, cracked skin - skin rash, blisters - burning pain - blistering, itchy, and red eyes	- tired - numbness -heart palpitations - sweat - tears - dribbling - runny nose
Group 2	- eye twitch - blurred vision - chest pain - nausea, vomiting - stomach ache	- diarrhea - muscle weakness - cramp - trembling hands - stagger	
Group 3	- seizures - blackout - unconscious		

Source: Division of Occupational and Environmental Diseases, Department of Disease Control [8].

Table 2. Health risk levels of farmers determined by pesticide use behavior and severity of acute symptoms after pesticide exposure

Severity of acute symptoms after pesticide exposure	Behavioral score		
	Low (15 – 24 Score)	Moderate (25 – 30 Score)	High (31 – 45 Score)
Asymptomatic	Low	Moderate	Relatively high
Show any signs of group1 symptoms (1 or more)	Moderate	Relatively high	High
Show any signs of group 2 symptoms (1 or more)	Relatively high	High	High
Show any signs of group 3 symptoms (1 or more)	High	High	Very high

Source: Division of Occupational and Environmental Diseases, Department of Disease Control [8].

Table 3. Health risk levels of farmers determined by pesticide use behavior and blood cholinesterase levels

Blood cholinesterase levels	Behavioral score		
	Low (15 – 24 Score)	Moderate (25 – 30 Score)	High (31 – 45 Score)
Normal	Low	Moderate	Relatively high
Safe	Moderate	Relatively high	High
At risk	Relatively high	High	High
Unsafe	High	High	Very high

3. Results and Discussion

3.1. Pesticide Usage and Working Behavior

Table 4. Farmer behavior while using pesticides (n=195)

Description	Practice (Frequency (%))		
	always	sometimes	never
1. Utilize insecticides on farm *	57(29.23)	116(59.49)	22(11.28)
2. Spray herbicides *	59(30.26)	112(57.43)	24(12.31)
3. Use inappropriately sealed or leaky chemical containers that cause a spray leak. *	5(.256)	38(19.49)	152(77.95)
4. Have been working despite having been exposed to pesticides *	31(15.90)	83(42.56)	81(41.54)
5. Clothes are soaked with pesticides while working *	4(2.05)	86(44.10)	105(53.85)
6. Have symptoms after using pesticides *	2(1.02)	42(21.54)	151(77.44)
7. Smoke tobacco or cigarettes while working *	3(1.54)	4(2.05)	188(96.41)
8. Eat and drink in the workplace *	3(1.54)	57(29.23)	135(69.23)
9. Drink alcohol in the workplace *	7(3.59)	5(2.56)	183(93.85)
10. Read container labels before utilizing chemicals	144(73.85)	47(24.10)	4(2.05)
11. Wear chemically resistant rubber gloves when handling pesticides	150(76.92)	33(16.92)	12(6.16)
12. Wear chemically sealed boots or shoes	155(79.49)	29(14.87)	11(5.64)
13. Always wash hands before eating or drinking	154(78.98)	26(13.33)	15(7.69)
14. Immediately change clothes at the workplace after spraying	146(74.87)	27(13.85)	22(11.28)
15. Take a shower immediately after work at the workplace where clothes are soaked with chemicals	149(76.41)	25(12.82)	21(10.77)

Note: * indicates a negative question

Table 5. Levels of farmers' pesticide use behavior (n=195)

Behavior levels	No. of farmers	Percent (%)
Low	150	76.92
Moderate	33	16.93
High	12	6.15

Of the 195 participants, 79.49% wore boots or shoes, 78.98% washed their hands before eating or drinking, and 76.22% wore chemical-resistant rubber gloves while handling pesticides. The results indicate that 30.26% of the participants sprayed herbicides, 29.23% used insecticides on their farms, and 15.90% were constantly exposed to pesticides while working (Table 4). It was found that 76.92% of the participants had low pesticide use behavior, while 16.93% and 6.15% had moderate and high, respectively (Table 5).

3.2. Acute Symptoms Caused by Exposure to or Use of Pesticides

Table 6. Acute symptoms caused by exposure to or use of pesticides among farmers (n=195)

Symptoms	No. of farmers	Percent (%)
Asymptomatic	173	88.72
Show signs of symptoms	22	11.28
- Show any signs of group 1 symptoms (1 or more)	20	90.91
- Show any signs of group 2 symptoms (1 or more)	2	9.09

Of the 195 farmers, 88.72% reported no symptoms after pesticide use or exposure, while 11.28% reported signs of symptoms. Of those who reported the symptoms, 90.91% experienced group 1 symptoms (Table 6).

3.3. Blood Cholinesterase Level Results

Table 7. Blood cholinesterase levels among farmers (n=195)

Blood cholinesterase levels	No. of farmers (%)
Normal	0(0.00)
Safe	0(0.00)
At risk	4(2.05)
Unsafe	191(97.95)

Of the 195 farmers, 97.95% had an unsafe blood cholinesterase level, and 2.05% were at the at-risk level (Table 7).

3.4. Risk Assessment Results from Model 1 & Model 2

Of the 195 individuals, 65.64% were classified as having low risk, while 26.67% and 7.69% were at moderate and relatively high-risk levels, respectively (Table 8). The findings show that 94.36% of the farmers were at the high-risk level, while 5.13% and 0.51% had very high and relatively high risks, respectively (Table 9). The proportion of health risks in Model 1 (symptoms × behavior at work) and Model 2 (cholinesterase levels × behavior at work) among the 195 farmers was found to be significantly different at the 0.05 level (Figure 1) (Stuart-Maxwell Chi-square =130.03, p-value < 0.001) (Table 10).

Table 8. Health risk levels of farmers determined by the severity of acute symptoms after pesticide exposure (n=195)

Health risk levels	No. of farmers	Percent (%)
Low	128	65.64
Moderate	52	26.67
Relatively high	15	7.69
High	0	0.00
Very high	0	0.00

Table 9. Health risks of farmers determined by blood cholinesterase levels (n=195)

Health risk levels	No. of farmers	Percent (%)
Low	0	0.00
Moderate	0	0.00
relatively high	1	0.51
high	184	94.36
very high	10	5.13

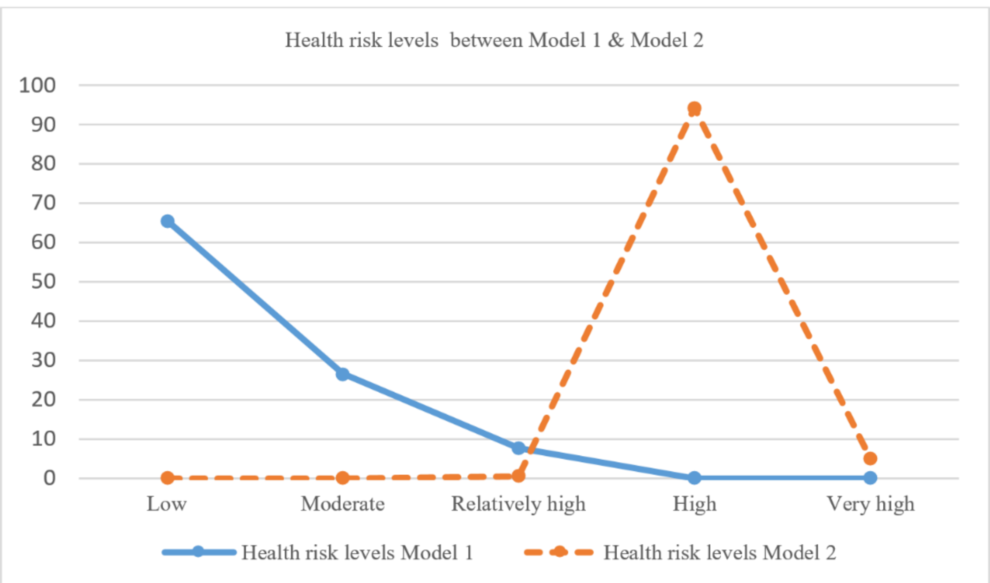

Figure 1. Health risk levels between Model 1 & Model 2

Table 10. Comparison between Model 1and Model 2 using the Stuart-Maxwell test)n=195(

Health risk assessment models	Health risk levels					Stuart-Maxwell Chi-square	p-value
	Low	Moderate	Relatively high	High	Very High		
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)		
Model 1 (symptoms × behavior at work)	128(65.64)	52(26.67)	15(7.69)	0(0.00)	0(0.00)	130.03	<0.001
Model 2 (cholinesterase levels × behavior at work)	0(0.00)	0(0.00)	1(0.51)	184(94.36)	10(5.13)		

The research compares the results of two pesticide-associated health risk assessment models: Model 1 and Model 2. Recommended by the Bureau of Occupational and Environmental Diseases, Model 1 gathers information from a questionnaire)the Nor Bor Kor. 1-56 Form(and assesses risks based on the severity of acute symptoms following pesticide application or exposure. Developed by the researchers, Model 2 takes into account blood cholinesterase levels in the farmers which are believed to give a more accurate result of the farmers' pesticide exposure risks than the questionnaire that inquires about abnormal symptoms. According to the study, 88.72% of the farmers reported no acute symptoms after using or being exposed to pesticides, whereas 11.28% reported abnormal symptoms. Of the individuals in the latter group, 90.91% reported having group 1 symptoms. When the pesticide exposure risk assessment was placed into a matrix with behavioral scores, it was found that 92.31%of the farmers had low and moderate health risks. This is in accordance with the findings of a study conducted in 2020, which evaluated pesticide-associated health risks among vegetable farmers in Khi Lek Subdistrict of Ubon Ratchathani Province, following the guidance provided by the Bureau of Occupational and Environmental Diseases.The findings indicate that most farmers (81.67%) had low levels of exposure to health risks [10]. It is clear that the abnormal symptoms that the individual farmers experienced varied depending on a variety of factors such as their personal characteristics)gender, age, weight(, their sensitivity and resistance to chemicals, exposure pathways, length of exposure, and the type and amount of chemicals they were exposed to. These factors can discriminate the different levels of severity of the symptoms the farmers experience after being exposed to pesticides [15-17]. In the risk assessment that focuses on abnormal symptoms, when the farmers reported no symptoms, it followed that they exhibited a low level of pesticide exposure.

However, the blood cholinesterase level test shows that 97.95% of the farmers had unsafe cholinesterase levels. This is in accordance with the research by Bintaleb et al., which found that 93.54% of the farmers who utilized manure for their agricultural work had unsafe blood cholinesterase levels, and 6.45% were at the at-risk level [18]. When the farmers are exposed to pesticides, acetylcholinesterase (AChE) can be acutely inhibited by organophosphate and carbamate, which bind covalently to a serine residue in the enzyme active site [19]. An abnormal blood cholinesterase level can be detected when reactive paper is screened for the activity of the enzyme [20]. The abnormality of blood cholinesterase levels was assessed using the researchers' developed model. As a result, it was revealed that the majority of the farmers (94.36%) were at high risk, while 5.13% were at a very high risk. When the outcomes of the two risk assessment models were compared using the Stuart-Maxwell test, it was found that they were statistically different (Stuart-Maxwell Chi-square, p-value < 0.001).

4. Conclusions

This study implies that assessing farmers' health risks of pesticide exposure by gathering information about the severity of abnormal symptoms from a questionnaire may not be sufficient to make judgments regarding farmers' health risks. For greater accuracy, the results of blood cholinesterase level tests should be taken into account when assessing risks in areas where farmers have been consistently and for a long time using chemicals.

Acknowledgments

This research was a collaboration between Ubon Ratchathani University and Nong Tae Health Promoting Hospital. The authors would like to express their gratitude to the farmers in Khi Lek Subdistrict and the College of Medicine and Public Health at Ubon Ratchathani University for funding this study.

REFERENCES

[1] Trang, A., Khandhar, P. B. Physiology, Acetylcholinesterase. [Internet] 2022. [Cited 2022 Mar. 18] Available from https://www.ncbi.nlm.nih.gov/books/NBK539735/

[2] Lee, S., Barron, M. G. "A mechanism-based 3D-QSAR approach for classification and prediction of acetylcholinesterase inhibitory potency of organophosphate and carbamate analogs", Journal of Computer-Aided Molecular Design, Vol. 30, no. 4, pp. 347-363, 2016. https://doi.org/10.1007/s10822-016-9910-7

[3] Colović, M. B., Krstić, D. Z., Lazarević-Pašti, T. D., et al. "Acetylcholinesterase Inhibitors: Pharmacology and Toxicology", Current Neuropharmacology, Vol. 11, no. 3, pp. 315-335, 2013. https://doi.org/10.2174/1570159x11311030006

[4] Lott, E. L., Jones, E. B. Cholinergic Toxicity. [Internet] 2022. [Cited 2022 Mar. 18] Available from https://www.ncbi.nlm.nih.gov/books/NBK539783/

[5] Robb, E. L., Baker, M. B. Organophosphate Toxicity. [Internet] 2022. [Cited 2022 Mar. 25] Available from https://europepmc.org/article/NBK/nbk470430#free-full-text

[6] Peter, J. V., Sudarsan, T. I., Moran, J. L. "Clinical features of organophosphate poisoning: A review of different classification systems and approaches", Indian Journal = of Critical Care Medicine, Vol. 18, no. 11, pp. 735-745, 2014. https://doi.org/10.4103/0972-5229.144017

[7] Mostafalou, S., Abdollahi, M. "Pesticides: an update of human exposure and toxicity", Archives of Toxicology, Vol. 91, pp. 529-599, 2017. https://doi.org/10.1007/s00204-016-1849-x

[8] Division of Occupational and Environmental Diseases, Department of Disease Control. Farmer's work risk assessment form from pesticide exposure. [Internet] 2022. [Cited 2022 Apr. 11] Available from http://envocc.ddc.moph.go.th/uploads/31858/1-56.pdf.

[9] The Office of Disease Prevention and Control 10, Ubon Ratchathani. The preventive, development, and operations for disease control 2017, in collaboration with the province. [Internet] 2022. [Cited 2022 Apr. 11] Available from https://odpc10.ddc.moph.go.th/wp- content/uploads/2018/01/20180117_08

[10] Boonkhao, L., Wongsafu, S. "Health risk assessment of pesticide exposure among vegetable farmers in Khi lek Subdistrict, Muaeng District, Ubon Ratchathani Province", Journal of Safety and Health, Vol. 13, no. 2, pp. 93-106, 2020.

[11] Boonkhao, L., Baukeaw, W. "Prevalence of abnormal serum cholinesterase among the vegetable farmers in a district in Ubon Ratchathani Province", Naresuan Phayao Journal, Vol. 13, no. 3, pp. 59-65, 2020.

[12] Lemeshow, S., Hosmer, D. W., Klar, J., et al. "Adequacy of sample size in health studies", John Wiley & Sons Ltd, 1990.

[13] Division of Occupational and Environmental Diseases, Department of Disease Control. Knowledge of cholinesterase reactive paper test for risk assessment of pesticide exposure. [Internet] 2022. [Cited 2022 Feb 27]Available from http://envocc.ddc.moph.go.th/uploads/media/manual/Crp.pdf

[14] Devon, H. A., Block, M. E., Moyle-Wright, P., et al. "A psychometric toolbox for testing validity and reliability", Journal of Nursing Scholarship, Vol. 39, no. 2, pp. 155-64, 2007. https://doi.org/10.1111/j.1547-5069.2007.00161.x

[15] Jeiplian, W., Piaseu, N., Sirivarasai, J., et al. "Use of insecticide, health perception and health status among farmers exposed to insecticide", Journal of Nursing Science Chulalongkorn University, Vol. 29, no. 3, pp. 89-100, 2017.

[16] Kim, K. H., Kabir, E., Jahan, S. A. "Exposure to pesticides and the associated human health effects", Science of the Total Environment, Vol. 575, pp. 525-535, 2017. https://doi.org/10.1016/j.scitotenv.2016.09.009

[17] Jensen, H. K., Konradsen, F., Jørs, E., et al. "Pesticide use and self-reported symptoms of acute pesticide poisoning among aquatic farmers in Phnom Penh, Cambodia", Journal of Toxicology, Vol. 2011, pp. 1-8, 2011.https://doi.org/10.1155/2011/639814

[18] Bintaleb, R., Prayonghom, J., Wonchaitha, S., et al. "Factors related to serum cholinesterase level and health education of insecticide usage among agriculturists in Wiang Kaen District, Chiang Rai Province, Thailand", Journal of Health Science and Alternative Medicine, Vol. 1, no. 2, pp. 7-14, 2019.

[19] Amin, D. M., Abaza, M. T., El Azawy, D. S., et al. "Morbidity and Mortality Indicators in Acute Organophosphate Poisoning in Zagazig University Hospital, Egypt: Retrospective Study", Occupational and Environmental Medicine, Vol. 6, no. 4, pp. 130-140, 2018. https://doi.org/10.4236/odem.2018.64011

[20] Thetkathuek, A., Jaidee, W. "Factors that contribute to insecticide poisoning among immigrant agricultural workers in Thailand", International Journal of Occupational and Environmental Health, Vol. 23, no. 1, pp. 60-70, 2017. https://doi.org/10.1080/10773525.2017.1421301.