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Original Article

Pesticide Contamination in Blood of Vegetable Farmers is Associated with Age, Pre-Harvest Interval, and Risk Behaviors

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ABSTRACT

Pesticides are commonly used in commercial agriculture. Organophosphates (OPPs) are one of the most imported pesticides in Thailand. OPP contamination in the human body is inversely determined by acetylcholinesterase (AChE) levels in blood circulation. Multiple factors determine OPP bioaccumulation in the human body. This present study aimed to investigate the association between levels of knowledge, behaviors, and personal characteristics of vegetable farmers with levels of pesticide contamination in the farmers' blood. Participants in this descriptive cross-sectional study were 219 vegetable farmers from Maha Sarakham province, Thailand using questionnaires on knowledge and behaviors on pesticide uses; and personal characteristics data. The level of blood AChE was measured by a reactive paper test kit. Association between each factor was analyzed by χ^2 tests with a significant level at $P < 0.05$. Results show that the levels of pesticide contamination in 219 vegetable farmers were significantly associated with age and pre-harvest interval. The risk levels of behaviors were also significantly associated with the levels of pesticide contamination (not reading labels and instructions, mixing pesticides with bare hands, not checking the wind direction during spraying, and not wearing correctly. In conclusion, levels of OPP contamination are associated with advancing age, pre-harvest interval (PHI), and risky behaviors. Close monitoring of these factors in vegetable farmers should be implemented.

GRAPHICAL ABSTRACT

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Introduction

Pesticides are chemicals commonly used in agricultural industries worldwide. After use, pesticide residues contaminated in environments can be hazardous to the health of consumers and farmers. In 2020, Thailand imported agricultural chemicals approximately 900,000,000 US$, accounting for 40% growth rate compared to 2019 [1]. The most common pesticides are organophosphates (OPPs), which many farmers have used without appropriate handling [2,3]. OPPs extinguish insects by inhibiting acetylcholinesterase (AChE), an enzyme hydrolyzing the neurotransmitter acetylcholine (Ach) into choline and acetate after activation of acetylcholine receptors (AChRs) at the postsynaptic membrane. This inhibition results in overstimulation of the neuromuscular system. Bioaccumulation of OPP in the human body is manifested by reduced blood AChE level. Acute OPP toxicity causes diarrhea, vomiting, muscle tremors, and confusion [4]. Chronic accumulation of low doses of OPPs is associated with neurotoxicity, anxiety, and metabolic diseases [5, 6].

In principle, every pesticide has a pre-harvest interval (PHI), the number of days required to lapse between the final pesticide application date and the harvest date [7]. On the harvest day, it is required that detectable concentration of the pesticide must be below the maximum residue limits (MRLs, expressed in μg/kg), the highest levels of residues expected to be found in food products when the pesticide is used following its label, set by the Food and Agriculture Organization-World Health Organization (FAO-WHO) [8]. The PHI values are different among types of OPPs and crops. For example, PHIs of quinalphos in yard long bean, eggplant, and cabbage are 7, 10, and 12 days after spraying (DAS), respectively. Meanwhile, PHIs of malathion are 7 DAS for yard long bean and eggplant, but 10 DAS for cauliflower [9]. However, the PHI in vegetables is maximally 12 DAS. Based on the PHIs reported by the study of Prodhan and colleagues, the toxicity levels of pesticides in vegetables have been categorized into 4 groups, i.e., 0-2 days = highly toxic, 3-7 days = moderately toxic, 8-14 days = slightly toxic, and 15-30 days = non-toxic [10].

Our previous study showed that OPP contamination in the blood of vegetable farmers was not associated with their knowledge and behaviors on pesticide use despite the high rate of risk and unsafe blood AChE levels [11]. To this end, however, details of PHIs, specific knowledge and behaviors related to pesticide use and cropping, and possible poisoning symptoms have not been reported. Therefore, this research was aimed to investigate the association of health problems, health knowledge, and behaviors with levels of OPP contamination in the blood of vegetable framers in the local community of Thailand.

Materials and Methods

Study design, participants, and ethical issue

Participants in this cross-sectional research were 219 vegetable farmers from Kosumphisai, Chuenchom, and Kantarawichai districts, Maha Sarakham, Thailand. Inclusion criteria were 1) age ≥ 18 years old, and 2) being vegetable farmers. All procedures have been voted by 2 reviewers, approved by the Mahasarakham University Ethics Committee for Research Involving Human Subjects, and endorsed by the chairperson Asst. Prof. Ratree Sawangjit (No.127/2020).

Questionnaires

The questionnaires of 1) knowledge on pesticide uses (Table 1), 2) behaviors on pesticide uses (Table 2), and 3) personal characteristics data were approved for content validity by 3 experts in Nutrition and Occupational Health. The content validity has been confirmed by the index of item-objective congruence (IOC). Only the items with IOC scores ≥ 0.5 were qualified for the questionnaires. The items with Cronbach's α ≥ 0.7 were accepted and used in the questionnaires.

Blood Sampling and Acetylcholinesterase Level Measurements

To detect AChE in the body from exposure to OPPs, a reactive paper test kit was from The Government Pharmaceutical Organization, Ministry of Public Health, Thailand. Blood samples were taken from a fingertip by public health officers. The paper color changes were compared with the standard and divided into 4 levels of AChE. Suppose the test paper changed to the yellow, yellow-green, green, and blue color. In that case, it can be interpreted to normal, safe, risky, and unsafe levels, respectively as previously shown [11]. Samples were collected from October-December 2020, the spraying and harvesting periods.

Statistical analyses

The data was employed descriptive statistics, then the relationship of each categorical data was analyzed by χ^2 tests. The level of statistical significance was $P < 0.05$. All data were analyzed by SPSS Statistics version 18.

Table 1: Questionnaires of knowledge on pesticide use

NO.	Items	Correct knowledge (%)
1	**Before using the pesticides** Pesticides should be stored in a safe and secure place.	95.4
2	In selecting a suitable pesticide, farmers should choose a type that has low toxicity to humans and animals but is toxic to the unwanted pest.	92.2
3	Pesticides can be safely mixed by bare hand stirring.	94.1
4	Pesticides can be mixed inside the house or in spaces under the same roof.	92.7
5	A picture of a skull and crossbones on a package label indicates that a product is dangerous to humans.	95.4
6	A clogged pesticides nozzle can be cleared by blowing through it by mouth.	94.5
7	**While using pesticides** Frequent spraying of pesticides risks causing an accumulation of toxins in the body.	95.0
8	The use of high concentrations of pesticides can result in a significant increase in the user's exposure to toxins.	98.2
9	Pesticide should not be sprayed during strong winds.	84.9
10	When pesticides splash into the eyes, a farmer can use a handkerchief or tissue paper to wipe them away.	67.1
11	Wearing a cloth hood over their head while spraying pesticides will not prevent harm.	77.6
12	**After using pesticides** Immediately (within 10 min) after spraying pesticides, farmer should not drink 81.7water.	71.2
13	If their skin has encountered spilled pesticides, a farmer should immediately wash thoroughly with soap and water.	93.2
14	The appearance of a rash after using pesticides is not serious and requires no action.	81.7
15	Used pesticide containers can be washed and safely used as food or drinking water containers.	81.7
16	Farmer can safely dispose of empty pesticides containers by crushing and burying them in prepared holes to be entirely covered by soil.	81.7

Table 2: Questionnaires of behaviors on pesticide uses

NO.	Items	Mean practice score (SD)
1	**Before using chemical pesticides** The pesticides that farmer buys are appropriately labeled with a warning sign, chemical name, manufacturer name, and registration number.	2.70 (0.67)
2	Farmer reads labels and user instructions to ensure farmer understands the guidelines before using pesticides.	2.73 (0.64)
3	Farmer mixes pesticides to the correct concentration as indicated in the user instructions.	2.65 (0.69)
4	Farmer checks their work gloves for holes by filling them with water and gently squeezing them before use.	2.42 (0.76)
5	Farmer mixes pesticides with their bare hands before use.	2.72 (0.65)
6	After the farmer has mixed pesticides, they wash their hands thoroughly with soap and water.	2.76 (0.61)
7	**While using pesticides** When farmers are spraying pesticides, do farmers note the wind direction, being careful not to let the chemical blow towards the farmers?	2.77 (0.62)
8	When farmers spray pesticides, they reduce the danger of exposure by wearing long-sleeved shirts, long trousers, a face mask, and shoes.	2.79 (0.60)
9	Farmer wears rubber boots at least half boot height when spraying pesticides.	2.72 (0.64)
10	Farmer wears elbow-length rubber gloves when spraying pesticides.	2.61 (0.74)
11	Farmer wears plastic safety goggles to prevent pesticides from getting into their eyes.	2.51 (0.80)
12	Farmer wears a full-face respirator mask to prevent farmer ingesting pesticides.	2.63 (0.73)
13	During spraying of pesticides, farmers take a break to: (please tick correct column for each item – Drink water, eat food, smoke tobacco, chew betel, drink alcohol	2.91-2.93 (0.34-0.40)
	After using pesticides	
14	Farmer wash their work clothes separately from their other laundry	2.77 (0.62)
15	Farmer immediately takes a shower or washes their whole body	2.76 (0.61)
16	Farmer clean and store their pesticide spraying equipment well away from other household items	2.70 (0.66)
17	Farmer sometimes leaves an empty pesticides container in their home awaiting disposal	1.69 (0.87)
18	Farmer disposes of used pesticide containers with general household garbage/waste.	2.74 (0.60)
19	Farmer disposes of used pesticide containers by burying them as a landfill.	1.83 (0.92)
20	Farmer disposes of used pesticide containers by burning them.	1.48 (0.79)
21	If farmer experience illness symptoms after applying pesticides, farmers wait to see if they will disappear without treatment	2.85 (0.46)
22	If farmers experience illness symptoms after applying pesticides, they buy medicine according to their understanding of what they need	2.81 (0.49)
23	If a farmer experience illness symptoms after applying pesticides, the farmer immediately seeks advice from a doctor	2.69 (0.69)

Results and Discussion

Relationship between personal characteristics of vegetable farmers and risk levels of pesticide contamination

Results showed that from totally 219 farmers, 120 participants were aged < 60 years old and 99 were ≥ 60 years old. Further χ^2 analysis showed that the levels of pesticide contamination in vegetable farmers were significantly associated with age (χ^2 = 13.54, P-value = .00) and pre-harvest interval (χ^2 = 21.59, P-value = .01) (Table 3).

Levels of knowledge on pesticide uses

Next, levels of knowledge on pesticide uses were analyzed. There was no significant association between the levels of knowledge and the levels of pesticide contamination (χ^2 = 4.14, P-value = .24).

Risk behaviors in pesticide uses

The results revealed that the risk levels significantly were associated with the levels of pesticide contamination (χ^2 = 25.26, P-value < .001) (Table 4). Before using chemical pesticides, the farmers did not read labels and user instructions and mixed pesticides with their bare hands. While using a pesticide, many of them did not note the wind direction. They also did not wear long-sleeved shirts, long trousers, a face mask, shoes, rubber boots, plastic safety goggles, or a full-face respirator mask. After using pesticides, many of them did not clean and store pesticide spraying equipment well away from other household items.

Table 3: Relationship between personal characteristics of vegetable farmers and risk levels of pesticide contamination

Characteristics	Normal	Safe	Risk	Unsafe	χ^2	P-value
Sex						
Male	8	11	28	38	4.19	.24
Female	24	22	40	48		
Age (years)						
< 60	26	21	33	40	13.54	<.001
≥ 60	6	12	35	46		
Educational level						
Primary school	17	26	42	56	13.81	.31
Secondary school	5	2	12	10		
High school	8	4	11	16		
Diploma	2	1	0	1		
Bachelor	0	0	3	3		
Working experience (year)						
< 1	1	1	0	3	7.11	.62
1-4	1	1	0	2		
5-9	2	2	3	1		
≥ 10	28	29	65	80		
Pre-harvest interval (days)						
≤ 2	8	15	40	54	21.59	.01
3-7	0	1	1	0		
8-14	0	0	2	2		
≥ 15	24	17	25	30		

Table 4: Risk levels of behaviors on pesticide uses

Risk practice level	Normal	Safe	Risk	Unsafe	χ^2	P-value
High	9	3	1	4	25.26	<.001
Moderate	20	28	64	76		
Low	3	2	3	6		

Characteristics of the farmers

The characteristics studied were the gender of the farmer, their age, their educational level, their working experience (in years) with using pesticides, and famer pre-harvest interval (in days). The result characterized factors related to the levels of pesticide contamination of farmers, which were significantly associated with age. The age of farmers was over sixty years old, Srishti Shrestha *et al.* found that the age-related hypothyroidism risk increased in the farmers who used organochlorine and organophosphate insecticides, particularly in those older than 62 years old [12]. Considering the pre-harvest interval, it was previously found associated with health risks, which signified that too early harvesting of the crops could maintain the presence of pesticides [13].

Knowledge on pesticide uses

This study discovered that most farmers come upon a high level of knowledge on pesticide use; even though it was not statistically related to the risk of pesticide use. However, some farmers had a low level of knowledge, such as 1) when pesticides splash into farmer's eyes, they can use a handkerchief or tissue paper to wipe it away, 2) immediately (within 10 min) after spraying pesticides, a farmer should not drink water and wearing a cloth hood over their head while spraying pesticides to prevent their harm. These results were found in several studies in the developing world. This was more disquiet for the farmers and field workers' exposure to pesticides [14]. It also occurred similarly in China – some Chinese farmers also lacked knowledge on pest management and pesticide use correlated with their excessive pesticide use [15].

Risk behaviors in pesticide uses

The risk levels were significantly associated with the levels of pesticide contamination. It indicated that high mean scores during spraying were also serious issues. While the farmers took a break; they were: 1) eating food, 2) smoking tobacco, 3) chewing betel, and 4) drinking alcohol. A similar study in Nepal found an association of the safe practice of chemical pesticides with farmers' knowledge and perception factors [16].

Conclusion

In conclusion, contamination levels of OPPs are associated with older adulthood, pre-harvest interval, and risky behaviors. Farmers over sixty years old might have a longer time of OPP exposure, posting higher risks of pesticide contamination. In addition, farmers should harvest their crops after spraying for 15 days. Furthermore, farmers should avoid oral ingestion of OPPs during spraying. These factors should be monitored and aware of in vegetable farmers in these local areas of Thailand. They should be educated on safety protocols in pesticide use.

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Potential Conflicts of Interest

The authors declare no conflict of interest.

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Authors' contributions

All authors contributed toward data analysis, drafting, and revising the paper and agreed to responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

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References

[1]. Kwonpongsagoon S., Katasila C., Kongtip P., Woskie S., *Int. J. Environ. Res. Public Health*, 2021, **18**:3046 [Crossref], [Google Scholar], [Publisher]

[2]. Kongtip P., Nankongnab N., Mahaboonpeeti R., Bootsikeaw S., Batsungnoen K., Hanchenlaksh C., Tipayamongkholgul M., Woskie S., *Ann. Work Expo. Health*, 2018, **62**:167 [Crossref], [Google Scholar], [Publisher]

[3]. Hongsibsong S., Prapamontol T., Xu T., Hammock B.D., Wang H., Chen Z.J., Xu Z.L., *Int. J. Environ. Res. Public Health*, 2020, **17**:4723 [Crossref], [Google Scholar], [Publisher]

[4]. 4.Eddleston M., Buckley N.A., Eyer P., Dawson A.H., *Lancet*, 2008, **371**:597 [Crossref], [Google Scholar], [Publisher]

[5]. Hung D.Z., Yang H.J., Li Y.F., Lin C.L., Chang S.Y., Sung F.C., Tai S.C., *PLoS One*, 2015, **10**:e0137632 [Crossref], [Google Scholar], [Publisher]

[6]. Voorhees J.R., Rohlman D.S., Lein P.J., Pieper A.A., *Front. Neurosci.*, 2016, **10**:590 [Crossref], [Google Scholar], [Publisher]

[7]. Lee J., Kim B.J., Kim E., Kim J.H., *Molecules*, 2019, **24**:2616 [Crossref], [Google Scholar], [Publisher]

[8]. Nguyen, T.T., Rosello C., Bélanger R., Ratti C., *Foods*, 2020, **9**:1468 [Crossref], [Google Scholar], [Publisher]

[9]. Prodhan M., Akon M., Alam S., *J. Environ. Anal. Toxicol.*, 2018, **8**:1 [Crossref], [Google Scholar], [Publisher]

[10]. Islam M.T., Hague M.A., *J. Bangladesh Agril. Univ.*, 2018, **16**:444 [Google Scholar]

[11]. Tudpor K., Pudto K., Khomnoi P., Wat-on P., *SWU J. Sci. Technol.*, 2019, **11**:1 [Publisher]

[12]. Shrestha S., Parks C.G., Goldner W.S., Kamel F., Umbach D.M., Ward M.H., Lerro C.C., Koutros S., Hofmann J.N., Beane Freeman L.E., Sandler D.P., *Environ. Health Perspect.*, 2018, **126**:097008 [Crossref], [Google Scholar], [Publisher]

[13]. Bakhsh K., Ahmad N., Tabasum S., Hassan S., Hassan I., *Sci. Total Environ.*, 2017, **598**:1058 [Crossref], [Google Scholar], [Publisher]

[14]. Rijal J.P., Regmi R., Ghimire R., Puri K.D., Gyawaly S., Poudel S., *Agriculture*, 2018, **8**:16 [Crossref], [Google Scholar], [Publisher]

[15]. Chen R., Huang J., Qiao F., *China Econ. Rev.*, 2013, **27**:15 [Crossref], [Google Scholar], [Publisher]

[16]. Kafle S., Vaidya A., Pradhan B., Jørs E., Onta S., *Int. J. environ. Res. Public Health*, 2021, **18**:4194 [Crossref], [Google Scholar], [Publisher]

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