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Effects of Alkaline Water to Blood Cholinesterase Level among Rice Farmers in Thailand

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Abstract

The farmers may be at risk for the adverse effects of pesticide exposure. The use of pesticides is associated with acute and chronic health effects, for example, respiratory problems, neurological condition and birth defects. This study aimed to investigate the association between farm activities related to pesticide exposure and blood ChE levels among farmers. An additional goal of the study was to examine and evaluate the effects of alkaline water on blood ChE levels among farmers. A quasi-experimental study with a two-group design was conducted from May 2023 to August 2023. A total of 100 farmers were recruited into either an intervention (n = 50) or a control (n = 50) group. The intervention group drank alkaline water for 12 weeks. A self-administered questionnaire was completed by both groups at pre-intervention, post-intervention, and follow-up. The chi-square test, Simple logistic regression and Wilcoxon Signed Rank Test were used for data analysis. The modeled odds of abnormal ChE activity increased significantly for frequency of harvesting (OR = 3.00, 95% CI: 1.18 - 7.62) and alkaline water drinking was a protective factor that may decrease abnormal ChE levels (OR = 0.08, 95%CI: 0.22 - 0.29). The blood ChE levels of farmers in week 12 were significantly higher than those of farmers in baseline. The results suggest that alkaline water is effective for removing organophosphate from farm activities related to pesticide exposure.

Keywords: Alkaline water; Pesticide; Agriculture; Cholinesterase; Farmer

1. Introduction

Pesticide use in Thailand was increasing significantly over the years, driven by the agricultural sector's push for increased productivity and the need to combat pests and diseases that threaten crops. Initially, the use of chemical pesticides in Thailand was introduced as part of modern agricultural practices to enhance crop yields, especially during the green revolution in the 1960s and 1970s (Pongsrihadulchai, 2019). According to the Food and Agriculture Organization of the United Nations (FAO) report, the total amount of pesticide use worldwide over the past 20 years tends to continually increase (Use & Trends, 1990). Studies have indicated that excessive pesticide application can lead to contamination of water bodies, soil degradation, and adverse health effects on agricultural workers (Hughes *et al.,* 2021).

The use of pesticides has been associated with a range of acute and chronic health effects among agricultural workers (Sapbamrer & policy, 2018). Potential risks include acute neurologic poisoning, chronic neurodevelopmental impairment, various forms of cancer, reproductive dysfunction, and possible disruptions to the immune and endocrine systems (Tawatsin, 2015). According to prior research found that, pesticide applicators had decreased Cholinesterase (ChE) levels, which were associated with their health, including depression symptoms, neurological symptoms, and poorer neurobehavioral performance (Abdel Rasoul *et al.,* 2008) (Ismail *et al.,* 2010) (Crane *et al.,* 2013) (Khan *et al.,* 2014) (Diane Schertler Rohlman *et al.,* 2014) (Suarez-Lopez *et al.,* 2019).

Alkaline water, characterized by a higher pH level normally between 8 and 9, contains minerals that the human body needs, such as calcium, sodium, magnesium, and potassium. Alkaline water is water with small molecules, making it easy for the body to absorb water for use in various parts. It also has a balanced acidity that is suitable for the human body, helping to protect the body from the destruction of excess acid that is the cause of various diseases. It also helps restore the body by flushing waste down to the cellular level.

Previous research has studied alkaline water consumption in relation to blood sugar levels in diabetes. The result revealed that the utilization of alkaline water can control blood sugar levels in people with type 2 diabetes mellitus (Siswantoro *et al.,* 2017). Weidman *et al.,* 2016 evaluated the effect of electrolyzed high-pH alkaline water on blood viscosity. The result shows that drinking high-pH alkaline water was shown to reduce systolic blood viscosity significantly. In addition, some studies suggest that the consumption of alkaline water could alter cholinesterase activity (Chan *et al.,* 2022). Alkaline water is also associated with various health claims, including its potential to improve bone density, especially in postmenopausal women with osteoporosis (Fasihi *et al.,* 2021) and assist in managing conditions like nonalcoholic fatty liver disease. Electrolyzed water treatment is effective for removing organophosphate, pyrethroid, and fungicide residues from fresh-cut vegetables (Liu *et al.,* 2021). As a result, farmers are at risk of pesticide exposure through a variety of routes, with serious health consequences.

The study on the relationship between alkaline water consumption and cholinesterase levels remains an interesting issue. The mechanism of two parameters involves various biochemical interactions within the body. Alkaline water might adjust enzyme activity due to its influence on systemic pH balance and mineral composition. The results from a previous study show that an excessively acidic diet potentially impairing cholinesterase performance (Dingová & Hrabovská, 2015). Therefore, drinking alkaline water is the alternative way to balance pH body. Earlier studies found that electrolyzed water is effective for removing some pesticides, such as organophosphate and pyrethroid (Liu *et al.,* 2021). Pesticides can affect decreased cholinesterase levels, drinking alkaline water can be considered a natural process to flush out chemicals from the body.

However, little is known about pesticide exposure patterns and health monitoring in farmers. Thus, this study aimed to evaluate the effects of alkaline water on blood ChE levels among farmers in Sukhothai, Thailand. This research is to be the first attempt in Thailand. The findings of this study can be implemented for the surveillance and prevention of pesticide-related health risks.

2. Methodology

2.1 Design, setting, and subjects

Quasi-experimental research with a two-group design was conducted. The subjects were randomly divided into two groups, including the intervention group and the control group. The intervention group received alkaline water, whereas the control group did not receive alkaline water. The intervention program was conducted from May 2023 to August 2023. The sample size for estimating a population proportion (Cochran & Inc, 1977) was determined by defining the estimated proportion at 50%, the confidence level at 95%, and the level of precision at 0.05%. The calculated sample size in each group was 38 students, with 10% added to prevent the effects of dropout and missing information in data analysis. Therefore, a total of 100 farmers were included, due to errors during blood sampling and testing. To recruit farmers, a systematic random sampling technique was applied. This study was conducted on farmers from Thub Pueng Sub-district, Sri Samrong District, Sukhothai Province, Thailand. The area of Sri Samrong District was purposefully selected because the favorable climate and geographical features provided conditions for cultivation throughout the year, with a large portion of the population engaged in various agricultural activities. These activities include crop cultivation by farmers who use pesticides to increase crop yields and protect against pests. Two groups of farmers were selected by simple random sampling based on their similar characteristics.

Each group has a sample size of at least 50 farmers. The list of farmers from Subdistrict Health Promoting Hospital and assigned a number ranging from 1 to N to each of the farmers who meets the inclusion criteria. Finally, the participants were selected using simple random sampling by computer random number generator. In summary, a total of 100 students were recruited from the intervention and control groups. There were 50 participants in each group. The inclusion criteria were farmers who did farm in the last 6 months. Permission from farmers was obtained using a consent form. The Research design is shown in Figure 1.

2.2 Data collection

Data was collected between May and August 2023. In-person interviews were conducted by the researchers. An interviewer-administered questionnaire contained the following sections: (a) demographic characteristics and (b) farm activities related to pesticide exposure. A registered nurse and the researcher collected fingerstick blood samples to assess ChE activity in serum using ChE reactive paper (GPO, Thailand), a standard technique recommended by the Bureau of Occupational and Environmental Diseases, Ministry of Public Health (Kanthawongwan *et al.,* 2019). For laboratory testing, this method had sensitivity, specificity, and positive predictive value of 89.89%, 95.65%, and 94.59%, respectively, while for field screening, it had 77.04%, 90.01%, and 90.38% (Chaiwong *et al.,* 2024). Blood ChE levels were classified into four levels based on color indication (Bigg's method): normal (yellow; ≥ 100 U/ml), safe (greenish yellow; 87.5 - 99.9 U/ml), risky (green; 75.0 - 87.4 U/ml), and unsafe (dark green; ≤ 75 U/ml). Unsafe and risky levels were defined as "abnormal", while safe and normal levels were defined as "normal".

2.3 Data analysis

Data analysis was carried out using Statistical Packages for the Social Sciences version 22.0. The significant level was set at $p < 0.05$. Chi-square test was used to analyze the difference between intervention and control groups on sociodemographic characteristics and farm activities related to pesticide exposure in categorical data. Wilcoxon Signed Rank Test was used to evaluate the effects of the alkaline water with the difference in median rank of blood ChE levels among the two time periods.

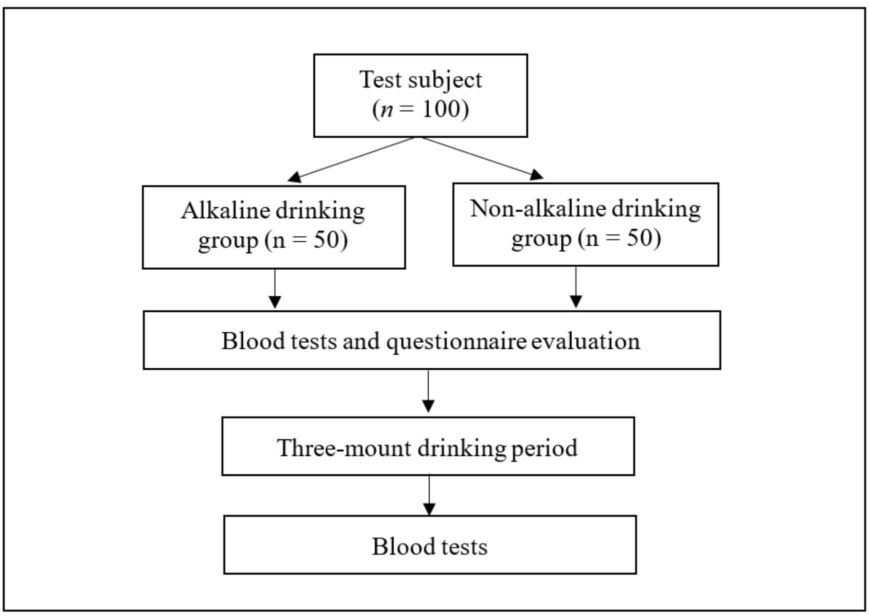

Figure 1. Research design

2.4 Ethical Considerations

Ethical approval was obtained from the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Ramkhamhaeng University (RU-HRE 66/0029). Before starting the intervention, farmers willingly consented to the informed consent form.

3. Results and Discussion

A total of 50 farmers in the intervention group and 50 farmers in the control group were included. The results are presented in three parts: (1) sociodemographic characteristics and (2) farm activities related to pesticide exposure. At baseline, the majority of farmers who did drink alkaline water (76.0%) and farmers who did not drink alkaline water (92.0%) aged more than 50 years old. Most of the farmers did drink beverages: 60.0% and 82.0% in the farmers who did drink alkaline water and farmers who did not drink alkaline water, respectively. The majority of farmers who did drink alkaline water (98.0%) and farmers who did not drink alkaline water (94.0%) had not smoked. Most of the farmers did not drink alcohol: 98.0% and 86.0% of the farmers who did drink alkaline water and farmers who did not drink alkaline water, respectively. A statistically significant difference was observed in the age, beverage intake and alcohol drinking between the two groups at baseline ($p < 0.05$). On the other hands, no statistically significant difference was observed on the smoking status between two groups at baseline ($p > 0.05$), as shown in Table 1.

More than half of the farmers who did drink alkaline water (54.0%) had yearly frequency of harvesting and the farmers who did not drink alkaline water (74.0%) had monthly frequency of harvesting. The majority of farmers who did drink alkaline water (74.0%) and farmers who did not drink alkaline water (56.0%) had less than 20 years of working experience. Most of the farmers who did drink alkaline water (50.0%) had less than once per year frequency of pesticides applying and the farmers who did not drink alkaline water (52.0%) had monthly or weekly frequency of pesticides applying. A statistically significant difference was observed on frequency of harvesting, frequency of pesticides applying and working experience with pesticides between two groups at baseline ($p < 0.05$). On the other hand, no statistically significant difference was observed on working experience between two groups at baseline ($p > 0.05$), as shown in Table 2.

The association between pesticide-related activities on farms and alkaline water drinking with blood ChE levels in farmers is shown in Table 3. The modeled odds of abnormal ChE activity increased significantly for frequency of harvesting (OR = 3.00, 95% CI: 1.18 - 7.62) and alkaline water drinking was a protective factor that may decrease

Table 1. Comparison of sociodemographic characteristics between the intervention and control groups at baseline

Variables	n (%)	Alkaline water drinking status	
		No (n= 50) n (%)	Yes (n= 50) n (%)
Age (Year)			
40 - 49	16 (16.0)	4 (8.0)	12 (24.0)
≥ 50	84 (84.0)	46 (92.0)	38 (76.0)
Beverage intake			
No	29 (29.0)	9 (18.0)	20 (40.0)
Yes	71 (71.0)	41 (82.0)	30 (60.0)
Smoking status			
No	96 (96.0)	47 (94.0)	49 (98.0)
Yes	4 (4.0)	3 (6.0)	1 (2.0)
Alcohol drinking status			
No	92 (92.0)	43 (86.0)	49 (98.0)
Yes	8 (8.0)	7 (14.0)	1 (2.0)

abnormal ChE levels (OR = 0.08, 95% CI: 0.22 - 0.29). After controlling for age in years, the modeled odds of abnormal ChE activity decreased but remained significant for each of the farm activities. It is true that frequency of pesticides applying and working experience with pesticides can increase the risk of pesticide exposure. The findings of this study suggest the need for pesticide training or an intervention to improve pesticide application practices, including the adoption of PPE, among farmer engaged in farm activities (McCauley *et al.,* 2002) (Diane S Rohlman *et al.,* 2020). Pesticide-related activities on

Table 2. Comparison of farm activities related to pesticide exposure between the intervention and control groups at baseline

Variables	n (%)	Alkaline water drinking status		p-value*
		No (n= 50) n (%)	Yes (n= 50) n (%)	
Frequency of harvesting				
Yearly	40 (40.0)	13 (26.0)	27 (54.0)	0.004*
Monthly	60 (60.0)	37 (74.0)	23 (46.0)	
Working experience				
< 20 years	65 (65.0)	28 (56.0)	37 (74.0)	0.059
≥ 20 years	35 (35.0)	22 (44.0)	13 (26.0)	
Frequency of pesticides applying				
Less than once per year	33 (33.0)	8 (16.0)	25 (50.0)	0.001*
Yearly	26 (26.0)	16 (32.0)	10 (20.0)	
Monthly or weekly	41 (41.0)	26 (52.0)	15 (30.0)	
Working experience with pesticides				
< 20 years	63 (63.0)	25 (50.0)	38 (76.0)	0.007*
≥ 20 years	35 (35.0)	25 (50.0)	12 (24.0)	

Note: Analyzed with a Chi-square test; *Statistical significance at $p < 0.05$.

Table 3. Association between pesticide-related activities on farms and alkaline water drinking with blood ChE levels in farmers

Exposure characteristics	Blood ChE levels		Crude OR (95% CI)	p-value	Adj OR[a] (95% CI)	p-value
	Normal n (%)	Abnormal n (%)				
Frequency of harvesting						
Yearly	15 (15.0)	25 (25.0)	1	0.021	1	0.026
Monthly	10 (10.0)	50 (50.0)	3.00 (1.18-7.62)*		2.91 (1.14-7.46)*	
Working experience						
< 20 years	18 (18.0)	47 (47.0)	1	0.399	1	0.506
≥ 20 years	7 (7.0)	28 (28.0)	1.53 (0.57-4.12)		1.41 (0.51-3.85)	
Frequency of pesticides applying						
Less than once per year	11 (11.0)	22 (22.0)	1		1	
Yearly	7 (7.0)	19 (19.0)	1.35 (0.44-4.19)	0.596	1.56 (0.48-5.01)	0.454
Monthly or weekly	7 (7.0)	34 (34.0)	2.42 (0.82-7.22)	0.110	2.56 (0.85-7.70)	0.094
Working experience with pesticides						
< 20 years	20 (20.0)	43 (43.0)	1	0.048	1	0.071
≥ 20 years	5 (5.0)	32 (32.0)	2.98 (1.01-8.78)*		2.75 (0.92-8.23)	
Alkaline water drinking status						
Did not drink	3 (3.0)	47 (47.0)	1	<0.001	1	<0.001
Drank	22 (22.0)	28 (28.0)	0.08 (0.22-0.29)*		0.08 (0.23-0.311)*	

Notes: [a] adjusted for age in years. *Statistical significance at $p < 0.05$

Table 4. Blood ChE levels in farmers at two study time points

Study time points	Baseline	Week12	Comparison of two times[a]
	Median n (%)	Median n (%)	
Participants (n)	50	50	
Blood ChE levels	49.47	55.81	< 0.001*

Notes: [a] Wilcoxon Signed Rank Test, *Association significant at p-value < 0.05

farms such as frequency of harvesting was found to be associated with ChE levels in Thai farmers. This may also be because a higher frequency of harvesting, reported participating in farm activities, leading to lower ChE activity. Regarding Alkaline water drinking was significantly associated with blood ChE levels in farmers. This finding was consistent with previous studies, the consumption of alkaline water could alter cholinesterase activity (Chan *et al.,* 2022). Our findings indicated occupational pesticide exposure among Thai farmers, which could contribute to their higher health risk.

The blood ChE levels of farmers in week 12 were significantly higher than those of farmers in baseline (Table 4). This finding was consistent with previous studies, the consumption of alkaline water could alter cholinesterase activity (Chan *et al.,* 2022).

4. Conclusion

The intensive testing of blood cholinesterase was conducted in farmers in Sukhothai, Thailand, to evaluate the efficiency of alkaline water on blood cholinesterase levels. The results of this present study showed that alkaline water in famers with risk for the adverse effects of pesticide exposure significantly improved the blood cholinesterase levels Quasi-experimental research when compare to the control group. Therefore, longer investigation is necessary to investigate this impact on blood cholinesterase levels. The findings of this study clearly represent the potential health-positive impact of alkaline water on blood cholinesterase levels and can be used to neutralize the adverse effect of pesticides and prevent abnormal ChE activity in farmers.

Regarding the study's limitations, this is a cross-sectional study in which causal relationships cannot be inferred. The study omitted many important details about pesticide exposure (for example, the last date of activities, hours and years of field work, length of time working with pesticides, pesticide active ingredient, and spraying method). Generalizability may be limited as a result of sampling by village unit in the investigated region. Therefore, larger scale studies covering broader geographical areas should be conducted as well as an investigation into the health effects of pesticide exposure among Thai farmers. Our study focused on blood ChE levels; future research should consider using additional biomarkers to assess other pesticide classes, such as metabolites.

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