

Analysis of Organophosphate Pesticide use and Cholinesterase Enzyme Levels Among Farmers in Banjarejo Village, Pakis District

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Abstract

Introduction: Organophosphate pesticides are widely used to control agricultural pests and may inhibit cholinesterase activity, making blood cholinesterase a useful biomarker of exposure. **Objective:** This study analyzed the use of organophosphate pesticides and cholinesterase levels among farmers in Banjarejo Village, Pakis District, Malang Regency. **Method:** This observational analytic study used a cross-sectional design. Nine active pesticide-spraying farmers were selected by purposive sampling. Data on age, sex, knowledge, spraying frequency and duration, personal protective equipment (PPE), working period, and pesticide dose were collected using questionnaires and observation. Cholinesterase levels were examined from blood samples. Fisher's Exact Test was used for bivariate analysis with $\alpha=0.05$. **Results and Discussion:** Seven respondents (77.8%) had normal cholinesterase levels and two (22.2%) had abnormal levels. Fisher's Exact Test showed no significant association between sex ($p=1.000$), knowledge ($p=0.444$), spraying frequency ($p=1.000$), working period ($p=0.444$), and pesticide dose ($p=1.000$) with cholinesterase levels. Age, spraying duration, and PPE use could not be statistically tested because their categories were constant. **Conclusion:** Most respondents had normal cholinesterase levels, but abnormal results were still found. The small sample and limited variation among exposure categories restrict statistical interpretation. Safe pesticide handling, correct dosing, and complete PPE use should nevertheless be strengthened.

Introduction

Agriculture is an important source of livelihood in Indonesia and pesticide use is commonly employed to control pests and maintain crop productivity. Organophosphate pesticides are of occupational health concern because exposure can occur through inhalation, ingestion, and dermal absorption, while their toxic action is associated with inhibition of cholinesterase enzymes in the nervous system (Wicaksono et al., 2023). Cholinesterase activity is therefore used as a biomarker for organophosphate and carbamate exposure among agricultural workers (Nambunmee et al., 2021). Unsafe pesticide practices may include incorrect dosing, inadequate personal protective equipment (PPE), and repeated spraying. A literature review by Lestari and Astutik (2023) reported that lower cholinesterase activity among horticultural farmers was associated in previous studies with factors such as age, knowledge, spraying frequency, working period, incomplete PPE, and longer spraying duration. Research among farmers in Indonesia has also documented abnormal cholinesterase results and associations with individual and environmental factors (Halisa et al., 2022; Munfiah et al., 2023).

Recent Indonesian studies demonstrate that pesticide exposure remains an occupational health issue. A study in Lembah Gumanti found 16.7% of farmers had abnormal cholinesterase levels and identified several exposure-related factors associated with reduced levels (Aulia et al., 2025). Another study among shallot-spraying farmers found 30.3% had abnormal cholinesterase activity and reported associations with insecticide type, working period, spraying frequency, education, and water intake (Sulistio et al., 2024). These findings indicate that local assessment remains important because exposure patterns and work practices differ between farming communities. Repeated or prolonged exposure to organophosphate pesticides may cause health effects beyond acute poisoning. Organophosphate exposure can inhibit acetylcholinesterase activity, resulting in the accumulation of acetylcholine and excessive stimulation of the nervous system. Clinical symptoms may include headache, dizziness, nausea, vomiting, excessive salivation, sweating, blurred vision, muscle weakness, tremor, and respiratory difficulties. In farmers, repeated exposure to organophosphate pesticides may also affect the nervous system and has been associated with neurological disorders such as peripheral nerve dysfunction and polyneuropathy. Therefore, monitoring cholinesterase activity is important as an indicator of organophosphate exposure and as part of occupational health surveillance among farmers.

Banjarejo Village, Pakis District, Malang Regency, is an agricultural area where farmers use pesticides during crop cultivation. Information on cholinesterase levels and pesticide-use characteristics among local spraying farmers is limited. Therefore, this study was conducted to analyze organophosphate pesticide use in relation to cholinesterase levels among farmers in Banjarejo Village, including age, sex, knowledge, spraying frequency and duration, PPE use, working period, and pesticide dose.

Method

This study used an observational analytic approach with a cross-sectional design. The study was conducted among active farmers who sprayed organophosphate pesticides in Banjarejo Village, Pakis District, Malang Regency. Purposive sampling was used based on the inclusion criteria described in the research protocol. The final sample consisted of 9 respondents.

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Primary data were obtained through questionnaires and observation covering age, sex, knowledge, spraying frequency, spraying duration, PPE use, working period, and pesticide dose. Cholinesterase level was obtained through blood examination and categorized into normal and abnormal according to the study's laboratory reference/cut-off. The dependent variable was cholinesterase level, while the independent variables were characteristics of pesticide use and respondent characteristics.

Cholinesterase activity was quantitatively determined in human serum using the DUMOLAB Cholinesterase reagent kit. The examination used a colorimetric, kinetic, decreasing reaction method at a wavelength of 405 nm and a temperature of 37°C. Venous blood samples were collected from the respondents and processed to obtain serum. Before examination, the reagents and samples were brought to room temperature. For the sample examination, 1,000 µL of Reagent 1 and 20 µL of serum sample were pipetted into a test tube. For the blank, 1,000 µL of Reagent 1 and 20 µL of distilled water were used. The mixture was homogenized and incubated for approximately 3 minutes at 37°C. Subsequently, 250 µL of Reagent 2 was added and mixed. The absorbance was measured after 2 minutes, followed by measurements at 1, 2, and 3 minutes. The change in absorbance per minute ($\Delta A/\text{min}$) was calculated according to the manufacturer's instructions. Cholinesterase activity was calculated using the formula: Cholinesterase activity (U/L) = $\Delta A/\text{min} \times 68,500$. When a calibrator was used, the cholinesterase activity was calculated based on the ratio of the sample absorbance change to the calibrator absorbance change multiplied by the calibrator concentration. The results were expressed in U/L and interpreted according to the reference values used in this study.

Univariate analysis was performed using frequency and percentage distributions. Bivariate analysis used Fisher's Exact Test at a significance level of $\alpha=0.05$ because the sample was small and several cells had low expected frequencies. Variables with only one category among all respondents could not be statistically tested because there was no comparison group.

Result and Discussion

1. Result

Table 1
Characteristics of the Respondent

No.	Variable	Distribution
1	Age	15–64 years: 9 (100.0%)
2	Gender	Male: 8 (88.9%); Female: 1 (11.1%)
3	Knowledge	Good: 4 (44.4%); Poor: 5 (55.6%)
4	Spraying frequency	Low: 7 (77.8%); High: 2 (22.2%)
5	Spraying duration	Safe: 9 (100.0%); Unsafe: 0 (0%)
6	PPE use	Complete: 0 (0%); Incomplete: 9 (100.0%)
7	Working period	<5 years: 4 (44.4%); >5 years: 5 (55.6%)
8	Pesticide dose	According to label: 1 (11.1%); Not according to label: 8 (88.9%)

Table 2
Distribution of cholinesterase levels

No.	Cholinesterase level	n	%
1	Normal	7	77.8
2	Abnormal	2	22.2
	Total	9	100.0

The examination showed that 7 of 9 respondents (77.8%) had normal cholinesterase levels, while 2 respondents (22.2%) had abnormal levels. The presence of two abnormal results indicates that not all spraying farmers had the same biological response to pesticide exposure.

Table 3
Pesticide-use characteristics according to cholinesterase level

Variable	Category	Normal	Abnormal	Total
Age	15-64	7	2	9
	> 64			
Gender	Male	6	2	8
	Female	1	0	1
Knowledge	Good	4	0	4
	Poor	3	2	5
Spraying frequency	Low	5	2	7
	High	2	0	2
Spraying duration	Safe	7	2	9
	Incomplete	7	2	9
PPE use				
Working period	<5 years	4	0	4
	>5 years	3	2	5
Dose	According to label	1	0	1
	Not according to label	6	2	8

2. Discussion

Cholinesterase levels: Most respondents had normal cholinesterase levels (77.8%), although two respondents had abnormal levels. This pattern is consistent with an Indonesian study among cabbage farmers in Jember that also identified two respondents with abnormal cholinesterase levels (Halisa et al., 2022). Normal results among most respondents do not necessarily mean that pesticide exposure is harmless; cholinesterase is influenced by the intensity and timing of exposure as well as individual and occupational characteristics. A systematic review reported that organophosphate exposure can reduce cholinesterase activity and that age, knowledge, PPE use, smoking behavior, and spraying duration have been considered relevant factors (Wicaksono et al., 2023).

Sex: There was no statistically significant association between sex and cholinesterase level ($p=1.000$). The sample was dominated by men, with only one female respondent, so the comparison between sexes was very limited. The absence of statistical significance should therefore be interpreted cautiously. Larger studies are needed to assess whether biological differences between sexes influence cholinesterase activity under comparable exposure conditions.

Knowledge: Knowledge was not significantly associated with cholinesterase level ($p=0.444$). Four respondents had good knowledge and all had normal cholinesterase levels, while two of the five respondents with poor knowledge had abnormal levels. Knowledge may influence safe work behavior, but it does not directly determine the biological level of cholinesterase. Actual implementation of safe practices, including PPE, dose compliance, and spraying technique, may be more directly related to exposure.

Spraying Frequency: Spraying frequency was not significantly associated with cholinesterase level ($p=1.000$). In the corrected dataset, the low-frequency group consisted of 5 respondents with normal and 2 with abnormal levels, while the high-frequency group consisted of 2 respondents, both with normal levels. This result should not be interpreted as evidence that spraying frequency has no effect in general. Nambunmee et al. (2021) found pesticide spraying to be an important predictor of reduced acetylcholinesterase activity. Differences in exposure intensity, pesticide type, work practices, and timing of blood collection may contribute to different findings.

Spraying Duration: All respondents were categorized as having safe spraying duration, so statistical testing was not possible. The absence of a comparison group means that the study cannot determine whether spraying duration is associated with cholinesterase level. Literature indicates that longer spraying duration can increase opportunities for pesticide exposure, but the present study had insufficient variation to test this relationship.

PPE Use: All nine respondents used PPE incompletely, and 7 had normal cholinesterase levels while 2 had abnormal levels. Because there was no respondent in the complete-PPE category, Fisher's Exact Test could not be performed. Therefore, this study cannot conclude that PPE use was unrelated to cholinesterase. PPE remains an important preventive measure because pesticide spraying can expose workers through dermal and inhalation routes (Nambunmee et al., 2021).

Working Period: Working period was not significantly associated with cholinesterase level ($p=0.444$). Although both abnormal results occurred among respondents with a working period greater than 5 years, the small sample limited the statistical power. A larger Indonesian study in Lembah Gumanti reported a significant association between working period and reduced cholinesterase (Aulia et al., 2025), illustrating that duration of occupational exposure may become more apparent when sample size and exposure variation are greater.

Pesticide Dose: Pesticide dose was not significantly associated with cholinesterase level ($p=1.000$). Eight respondents used doses based on estimation rather than the label, while only one followed the label. The two abnormal cholinesterase results occurred in the group not following the label, but this pattern was insufficient to demonstrate a statistical association. Correct dosing remains important because pesticide exposure depends not only on frequency but also on the amount and concentration of active ingredients encountered during mixing and spraying.

Overall, the findings should be interpreted in light of the study's limitations. The sample consisted of only 9 respondents, and several exposure variables were constant, preventing statistical comparison. The cross-sectional design also does not establish causality. Nevertheless, the study provides a local description of cholinesterase status and pesticide-use practices among active spraying farmers in Banjarejo. In addition to the statistical findings, the results should also be considered from an occupational health perspective. The use of organophosphate pesticides represents a potential occupational chemical exposure among farmers, particularly when spraying activities are performed repeatedly. Exposure may occur through dermal contact, inhalation, or accidental ingestion when pesticide handling and application practices are not carried out according to recommended safety procedures. Organophosphates exert their primary toxic effect by inhibiting acetylcholinesterase, an enzyme responsible for hydrolyzing the neurotransmitter acetylcholine. Inhibition of this enzyme may result in acetylcholine accumulation at nerve synapses and, at sufficient exposure levels, may lead to disturbances in the nervous system. Therefore, cholinesterase measurement can be used as one of the biomarkers for monitoring pesticide exposure among agricultural workers.

Although most respondents in this study had cholinesterase levels within the normal reference range, abnormal cholinesterase levels were still identified among some respondents. This finding is important from an occupational health perspective because decreased cholinesterase activity may indicate pesticide exposure that requires further attention and control. Repeated pesticide spraying may result in recurring occupational exposure, particularly when safe work practices and the proper use of personal protective equipment (PPE) are not consistently implemented. Therefore, normal cholinesterase levels among most respondents do not necessarily indicate the absence of occupational exposure or risk associated with pesticide use.

The findings regarding pesticide-use practices also indicate several occupational health concerns, particularly related to PPE use and pesticide dosage. Incomplete use of PPE may increase the possibility of pesticide contact with the skin and inhalation of pesticide droplets or vapors during mixing and spraying activities. Furthermore, the use of pesticide doses that do not comply with the product label may increase the amount of active substance applied, potentially increasing occupational exposure. Therefore, risk control should not rely solely on cholinesterase monitoring but should also include appropriate pesticide handling, compliance with recommended dosages, the consistent use of appropriate PPE, and education on safe pesticide application practices. Based on the identification of pesticides used by the respondents, the organophosphate pesticides found in this study contained the active ingredient curacron. These active ingredients belong to the organophosphate class and exert their toxic effects primarily through inhibition of acetylcholinesterase activity. The use of these active ingredients is relevant to occupational health because exposure may occur during pesticide preparation, mixing, spraying, and contact with recently treated crops. Therefore, identifying the active ingredients used by farmers is important for assessing the potential occupational health risks associated with organophosphate pesticide exposure.

Overall, the findings indicate that the assessment of pesticide-related occupational health risks should not be based solely on the statistical association between farmers' characteristics and cholinesterase levels. Other factors, including the type of active ingredient used, pesticide dosage, spraying frequency and duration, and PPE practices, should also be considered when assessing occupational exposure. This approach is important because cholinesterase biomonitoring is not only useful for determining the

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laboratory status of exposed workers but can also support preventive and control measures to reduce pesticide exposure and protect the health of agricultural workers.

Conclusion

Based on the findings of this study, the use of organophosphate pesticides among farmers in Banjarejo Village requires attention from an occupational health perspective because of the potential for exposure during pesticide application activities. Although most respondents had cholinesterase levels within the normal reference range, abnormal levels were still observed, indicating the need for continued monitoring of pesticide exposure. The analysis did not demonstrate a statistically significant association between the pesticide-use characteristics that could be analyzed and cholinesterase levels. Nevertheless, the presence of inappropriate pesticide dosing and incomplete PPE use indicates that work practices may still contribute to occupational exposure. Therefore, preventive measures should include compliance with pesticide label instructions, proper and complete use of PPE, education on safe pesticide handling and application, and periodic cholinesterase monitoring as part of occupational health protection for farmer

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