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## Analysis of Blood Cholinesterase Enzyme Levels Among Farmers

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### Abstract

Pesticides are chemical substances used to control or eradicate pests and are considered toxic compounds that may pose health risks to farmers. Organophosphate pesticides can enter the human body through the digestive system, respiratory tract via inhalation, and unprotected skin surfaces. This study aimed to analyze the association between educational level, knowledge, spraying position, spraying frequency, length of employment, and blood cholinesterase levels among farmers in Parigi Moutong Regency. This study employed an analytical observational design with a cross-sectional approach. A total of 41 pesticide-spraying farmers from Balinggi Jati Village were included as respondents using a purposive sampling technique. Data collection was conducted through interviews using structured questionnaires and blood cholinesterase examinations performed by health personnel from Prodia Laboratory, Palu. Data were analyzed using the Chi-square test. The results showed that there were no statistically significant relationships between age and blood cholinesterase levels ( $p = 0.846$ ), educational level ( $p = 0.879$ ), gender ( $p = 0.548$ ), length of employment ( $p = 0.854$ ), spraying frequency ( $p = 0.252$ ), spraying position ( $p = 0.132$ ), and knowledge level ( $p = 0.879$ ). In conclusion, age, gender, educational level, knowledge, spraying position, spraying frequency, and length of employment were not significantly associated with blood cholinesterase levels among farmers in Parigi Moutong Regency. Nevertheless, continuous education regarding safe pesticide use and the implementation of proper occupational safety practices remain important to minimize the risk of pesticide exposure among farmers.

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## 1. INTRODUCTION

Pesticides are generally defined as toxic chemical substances used to control harmful organisms that are detrimental to humans (Yadav, & Devi, 2017; Singh et al., 2022; Daraban, Hlihor, & Suteu, 2023; Khan et al., 2023). Although pesticides are poisonous substances, they play an important role in protecting agricultural products and increasing crop productivity by controlling pests and plant diseases (Bai, Wang, & Yuan, 2023; Barathi et al., 2024; Chowdhury, 2024). Globally, approximately 900 chemical compounds are used as pesticides with more than 45,000 formulations available worldwide. In Indonesia, more than 500 pesticide formulations have been officially registered and permitted for circulation, including 13 formulations categorized as restricted or highly hazardous pesticides (Marisa & Pratuna, 2018). The extensive use of pesticides in the agricultural sector has contributed significantly to increased agricultural production; however, improper handling and excessive exposure may pose serious health risks to farmers and surrounding communities.

Farmers are among the occupational groups most vulnerable to pesticide exposure because they are directly involved in pesticide mixing, preparation, and spraying activities. In addition, communities living near agricultural areas may also be indirectly exposed to pesticide residues through environmental contamination. Organophosphate pesticides are among the most widely used pesticides in agricultural spraying activities. These compounds can enter the human body through several routes, including ingestion via the digestive tract, inhalation through the respiratory tract, and dermal absorption through unprotected skin surfaces. Continuous or excessive exposure to organophosphate pesticides may lead to acute or chronic poisoning, which can be assessed through the measurement of cholinesterase enzyme activity in the blood (Yuandra, 2019).

Blood cholinesterase examination is widely recognized as an important biomarker for detecting pesticide poisoning among farmers. Cholinesterase is an enzyme responsible for hydrolyzing the neurotransmitter acetylcholine (ACh) into choline and acetic acid, a process required for restoring cholinergic neurons to their resting state after activation. Inhibition of cholinesterase activity due to organophosphate exposure may result in the accumulation of acetylcholine within synaptic junctions, leading to neurological disturbances, respiratory disorders, poisoning symptoms, and potentially death (Sari et al., 2018). Therefore, monitoring blood cholinesterase levels is essential for evaluating the occupational health risks associated with pesticide exposure among agricultural workers.

Several previous studies have investigated factors associated with decreased blood cholinesterase levels among farmers, including age, educational level, knowledge, spraying frequency, and length of employment (Dwiyanti, Darundiati, & Dewanti, 2018; Hermawan, 2018; Tambunan & Ritonga, 2020; Tutu, 2020). However, findings from previous studies remain inconsistent. Some studies reported significant associations between occupational exposure factors and cholinesterase levels, whereas others found no statistically significant relationships (Dwiyanti, Darundiati, & Dewanti, 2018; Hermawan, 2018; Tambunan & Ritonga, 2020; Tutu, 2020). In addition, most previous studies focused primarily on general pesticide exposure without specifically examining behavioral factors such as spraying position and farmers' knowledge regarding safe pesticide handling practices. Furthermore, studies investigating blood cholinesterase levels among farmers in Parigi Moutong Regency remain limited, despite the region's substantial agricultural activities and potential pesticide exposure risks. This condition indicates the existence of a research gap concerning the comprehensive evaluation of occupational and behavioral factors associated with blood cholinesterase levels among farmers in this area.

This study lies in its simultaneous analysis of educational level, knowledge, spraying position, spraying frequency, and length of employment in relation to blood cholinesterase levels among farmers in Parigi Moutong Regency. Unlike previous studies that mainly focused on demographic or exposure-related variables separately, this study integrates behavioral and occupational factors to provide a broader understanding of pesticide exposure risks among farmers. Therefore, this study aimed to analyze the association between educational level, knowledge, spraying position, spraying frequency, length of employment, and blood cholinesterase levels among farmers in Parigi Moutong Regency.

## 2. METHOD

This study employed an analytical observational design with a cross-sectional approach to analyze the association between educational level, knowledge, spraying position, spraying frequency, length of employment, and blood cholinesterase levels among farmers in Parigi Moutong Regency. The study was conducted from July to August 2023 in Parigi Moutong Regency, Indonesia. The target population consisted of farmers who were actively involved in pesticide spraying activities in the agricultural sector. The study sample included 41 farmers selected using a purposive sampling technique based on predetermined inclusion criteria, namely farmers who routinely used pesticides in farming activities, were willing to participate in the study, and provided informed consent. Farmers with incomplete data or who were not directly involved in pesticide spraying activities were excluded from the study.

Data collection was conducted using a structured questionnaire administered through direct interviews with respondents. The questionnaire collected information regarding respondents' demographic and occupational characteristics, including age, gender, educational level, length of employment, knowledge related to pesticide use, spraying frequency, and spraying position during pesticide application. Knowledge regarding pesticide use was assessed using several questions related to safe pesticide handling and occupational safety practices. Blood cholinesterase level examination was performed in collaboration with Prodia Laboratory, Palu, by trained health personnel using standard laboratory procedures. Blood samples were collected from each respondent to assess cholinesterase enzyme activity as an indicator of pesticide exposure and potential poisoning.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to describe respondent characteristics. Bivariate analysis was conducted using the Chi-square test to determine the association between independent variables and blood cholinesterase levels. Logistic regression analysis was subsequently performed to identify variables that potentially contributed to blood cholinesterase levels. A p-value of <0.05 was considered statistically significant.

This study received ethical approval from the Health Research Ethics Committee, Faculty of Dentistry, University of Jember, with ethical clearance number No. 2089/UN25.8/KEPK/DL/2023. All respondents provided informed consent prior to participation, and the study was conducted in accordance with research ethics principles, including confidentiality, anonymity, and voluntary participation.

## 3. RESULTS AND DISCUSSION

**Table 1.** Respondent Characteristics.

Variable	Category	n	%
Gender	Male	39	95.1
	Female	2	4.9

Variable	Category	n	%
Age	<45 years	19	46.3
	≥45 years	22	53.7
Education	Low	11	26.8
	High	30	73.2
Knowledge	Good	6	14.6
	Poor	35	85.4
Spraying Position	Against the wind direction	31	75.6
	Following the wind direction	10	24.4
Spraying Frequency	>2 times/week	7	17.1
	≤2 times/week	34	82.9
Length of Employment	>5 years	40	97.6
	≤5 years	1	2.4

Based on Table 1, most respondents were male, accounting for 39 individuals (95.1%), while only 2 respondents (4.9%) were female. Regarding age distribution, the majority of respondents were aged ≥45 years, totaling 22 individuals (53.7%), whereas 19 respondents (46.3%) were aged <45 years.

In terms of educational level, most respondents had a high level of education, with 30 individuals (73.2%), while 11 respondents (26.8%) had a low level of education. Based on knowledge regarding pesticides, the majority of respondents had poor knowledge, totaling 35 individuals (85.4%), whereas only 6 respondents (14.6%) had good knowledge.

Regarding spraying position, most respondents performed spraying against the wind direction, accounting for 31 individuals (75.6%), while 10 respondents (24.4%) sprayed following the wind direction. Based on spraying frequency, the majority of respondents sprayed ≤2 times per week, totaling 34 individuals (82.9%), whereas 7 respondents (17.1%) sprayed >2 times per week.

Regarding length of employment, almost all respondents had worked as farmers for more than 5 years, totaling 40 individuals (97.6%), while only 1 respondent (2.4%) had worked for ≤5 years.

**Table 2.** Association Between Respondent Characteristics and Blood Cholinesterase Levels Among Farmers in Parigi Moutong Regency, 2023.

Variable	Category	Blood	Blood	Total	p-value
		Cholinesterase Level ≥11.500 n (%)	Cholinesterase Level <11.500 n (%)		
Gender	Male	6 (15.4)	33 (84.6)	39	0.548
	Female	0 (0.0)	2 (100.0)	2	
Age	≥45 years	3 (13.6)	19 (86.4)	22	0.846
	<45 years	3 (15.8)	16 (84.2)	19	
Spraying Position	Against wind direction	6 (19.4)	25 (80.6)	31	0.132
	Following wind direction	0 (0.0)	10 (100.0)	10	

Variable	Category	Blood	Blood	Total	p-value
		Cholinesterase Level $\geq 11.500$ n (%)	Cholinesterase Level $< 11.500$ n (%)		
Knowledge Level	Good	1 (16.7)	5 (83.3)	6	0.879
	Poor	5 (14.3)	30 (85.7)	35	
Educational Level	High	4 (36.4)	7 (63.6)	11	0.879
	Low	2 (6.7)	28 (93.3)	30	
Spraying Frequency	>2 times/week	2 (28.6)	5 (71.4)	7	0.252
	$\leq 2$ times/week	4 (11.8)	30 (88.2)	34	
Length of Employment	>5 years	6 (15.0)	34 (85.0)	40	0.854
	$\leq 5$ years	0 (0.0)	1 (100.0)	1	

The results of the Chi-square analysis demonstrated that none of the examined variables showed a statistically significant association with blood cholinesterase levels among farmers in Parigi Moutong Regency ( $p > 0.05$ ). Variables including gender, age, spraying position, knowledge level, educational level, spraying frequency, and length of employment were not significantly related to decreased blood cholinesterase levels.

Most respondents had blood cholinesterase levels below 11.500 across all categories. Although respondents with higher spraying frequency and longer employment duration tended to show a greater proportion of low cholinesterase levels, these associations did not reach statistical significance. These findings suggest that factors beyond the variables analyzed in this study, such as intensity of pesticide exposure, type of pesticide used, compliance with personal protective equipment usage, and occupational safety practices, may play a more important role in influencing blood cholinesterase levels among farmers.

The results of this study showed that there was no statistically significant relationship between gender and blood cholinesterase levels among farmers in Parigi Moutong Regency ( $p = 0.548$ ). The absence of a significant association may have been influenced by the unequal distribution of respondents based on gender, where most respondents were male while the number of female respondents was relatively limited. In addition, both male and female farmers were involved in similar pesticide-related activities, such as mixing and spraying pesticides, resulting in relatively comparable levels of exposure. Consequently, the risk of decreased cholinesterase enzyme levels may not differ substantially between genders in this study population.

These findings are consistent with the study conducted by Wicaksono (2016), which also reported no relationship between gender and decreased blood cholinesterase levels. The study explained that women involved in agricultural activities were still exposed to pesticides, particularly when assisting in spraying activities, such as carrying hoses or walking behind male farmers during spraying processes. Therefore, female workers remained at risk of pesticide exposure despite not acting as the primary pesticide sprayers. This condition indicates that pesticide exposure among farmers is more strongly influenced by work activities and exposure intensity rather than gender differences alone.

Regarding age, the present study found no statistically significant relationship between age and blood cholinesterase levels among farmers ( $p = 0.846$ ). This finding is

in line with the study by Tutu (2020), which also reported no association between age and blood cholinesterase enzyme levels among farmers. Although increasing age is theoretically associated with declining metabolic and detoxification functions, the current study suggests that age alone may not directly influence cholinesterase enzyme activity. Other factors, such as the duration of pesticide exposure, frequency of spraying, and use of personal protective equipment, may play a more dominant role in determining cholinesterase levels among farmers.

Theoretically, increasing age may increase the risk of health disorders related to pesticide exposure due to reduced metabolic capacity and decreased detoxification functions. Furthermore, age-related decline in immune function may increase susceptibility to the toxic effects of pesticides (Tutu, 2020). However, age was not found to be significantly associated with cholinesterase levels in this study, indicating that both younger and older farmers may experience similar risks when exposed to pesticides under comparable working conditions. These findings emphasize that occupational exposure factors may contribute more significantly to cholinesterase changes than physiological aging alone.

The study conducted by Sitoresmi (2022) also supports these findings, reporting that age did not significantly affect cholinesterase enzyme activity among farmers in Gemblegan Village, Kalikotes District, Klaten Regency. The study explained that farmers often increased pesticide dosages beyond recommended levels to improve agricultural effectiveness, thereby increasing pesticide exposure risk regardless of age category. Such unsafe pesticide practices may elevate exposure risks even among relatively young farmers. Therefore, improper pesticide handling behaviors may have a greater influence on cholinesterase levels than demographic characteristics such as age.

In terms of spraying position, this study found no statistically significant relationship between spraying position and blood cholinesterase levels among farmers ( $p = 0.132$ ). This finding is consistent with the study conducted by Utami et al. (2021), which reported no statistically significant association between spraying direction relative to wind direction and cholinesterase enzyme levels based on Fisher's Exact Test. The absence of a significant relationship may indicate that other occupational factors, such as spraying duration, pesticide dosage, and use of protective equipment, have a stronger influence on pesticide absorption. In addition, farmers may have already adapted their spraying practices to reduce direct exposure during spraying activities.

Nevertheless, the study by Utami et al. reported contrasting findings, demonstrating a significant relationship between pesticide spraying practices relative to wind direction and blood cholinesterase levels ( $p = 0.004$ ). Spraying against the wind direction may cause pesticide particles to directly contact the worker's body, thereby increasing the risk of pesticide exposure and poisoning. This risk becomes greater when spraying tall crops or when personal protective equipment is not adequately used. In addition to affecting workers' health, inappropriate spraying direction may also contribute to environmental contamination due to pesticide residue accumulation on agricultural land.

The present findings also differ from those reported by Hermawan (2018), who found a significant relationship between spraying position and blood cholinesterase levels among guava farmers ( $p = 0.003$ ). The study emphasized that improper spraying position may substantially increase direct pesticide exposure among farmers. Farmers who spray against wind direction are more likely to inhale pesticide particles or experience direct skin contact with pesticides. Therefore, maintaining correct spraying techniques remains important to minimize occupational exposure risks among agricultural workers.

Regarding knowledge level, this study demonstrated no statistically significant relationship between knowledge and blood cholinesterase levels among farmers ( $p = 0.879$ ). These findings are supported by studies cited in Tutu (2020), which reported no association between knowledge level and cholinesterase enzyme activity among potato farmers in Wonosobo Regency. Similarly, Tutu (2020) found no significant relationship between knowledge level and blood cholinesterase enzyme activity among shallot farmers in Brebes Regency. The results suggest that possessing knowledge regarding pesticides does not necessarily guarantee safe pesticide handling practices among farmers.

However, theoretically, knowledge is considered an important determinant of health behavior. According to Green et al. (1980), adequate knowledge regarding pesticide use and management should encourage safer work practices and reduce the risk of pesticide exposure. The absence of a significant relationship in this study may indicate a gap between knowledge and actual implementation of safe practices in the field. Farmers with good knowledge may not consistently apply appropriate pesticide handling procedures due to work habits, limited resources, or lack of supervision.

Regarding educational level, the study found no statistically significant relationship between education and blood cholinesterase levels. These findings are consistent with the results reported by Wicaksono (2016), which indicated that educational level was not associated with blood cholinesterase enzyme levels. The study noted that most respondents had relatively low educational attainment, which is commonly associated with traditional agricultural mindsets (Wicaksono, 2016). Nevertheless, formal education alone may not directly determine occupational health behaviors related to pesticide exposure.

Similarly, Sari (2018) reported no relationship between educational level and pesticide poisoning. This finding suggests that pesticide exposure is not solely influenced by formal education, but also by work habits, exposure intensity, use of personal protective equipment, and adherence to occupational safety procedures. Farmers with higher educational levels may still experience pesticide exposure if safe work practices are not properly implemented. Therefore, practical occupational safety training may be more important than formal educational background alone in preventing pesticide poisoning.

Regarding spraying frequency, this study found no statistically significant relationship between spraying frequency and blood cholinesterase levels. However, these findings differ from those reported by Hardi (2020), who identified a significant relationship between pesticide spraying frequency and blood cholinesterase levels among vegetable farmers ( $p < 0.05$ ). The study explained that farmers who sprayed pesticides more than twice per week had a higher risk of pesticide exposure, which could contribute to decreased blood cholinesterase levels. Frequent pesticide spraying may increase cumulative exposure and consequently elevate the risk of pesticide toxicity among farmers.

Similar findings were reported by Widada (2016), who found that farmers spraying pesticides more than twice weekly had nearly 14 times greater risk of pesticide poisoning compared with those spraying two times or less per week. Increased spraying frequency may lead to greater cumulative pesticide exposure within the body. Continuous exposure over time may inhibit cholinesterase enzyme activity and increase the likelihood of toxic effects on the nervous system. Therefore, controlling spraying frequency remains important in reducing occupational pesticide exposure.

Regarding length of employment, this study found no statistically significant relationship between working duration and blood cholinesterase levels. These findings are consistent with the study conducted by Tambunan & Ritonga (2020), which also reported no relationship between working duration and decreased cholinesterase levels among

farmers in Gajah Pokki Village. The absence of a significant relationship may indicate that long-term employment does not necessarily reflect cumulative pesticide exposure if farmers consistently apply safe working practices. In addition, individual differences in pesticide handling behaviors may influence exposure outcomes more strongly than working duration alone.

However, the present findings differ from those reported by Samosir et al. (2017), who found a significant association between years of employment and balance disorders among horticultural farmers ( $p = 0.036$ ). The study indicated that farmers with longer working periods had a higher risk of health disorders due to long-term cumulative pesticide exposure. Prolonged exposure to pesticides over many years may gradually affect neurological and physiological functions among agricultural workers. Therefore, occupational exposure duration should still be considered an important factor in occupational health monitoring programs.

Furthermore, Dwiyanti, Darundiati, & Dewanti (2018) reported a significant relationship between length of employment and cholinesterase levels ( $p = 0.008$ ), with a negative correlation indicating that longer working duration was associated with lower cholinesterase levels. This finding suggests a cumulative effect of long-term pesticide exposure on farmers' health. Farmers who are exposed to pesticides continuously over extended periods may experience progressive inhibition of cholinesterase enzyme activity. Consequently, regular medical examinations and biological monitoring remain essential for farmers with prolonged occupational exposure to pesticides.

Overall, the findings of this study indicate that gender, age, spraying position, knowledge level, educational level, spraying frequency, and length of employment were not significantly associated with blood cholinesterase levels among farmers in Parigi Moutong Regency. Nevertheless, previous studies suggest that these factors may still contribute to changes in cholinesterase levels when accompanied by high pesticide exposure intensity, inadequate use of personal protective equipment, and unsafe work practices. The results highlight the importance of improving occupational safety behaviors and strengthening farmers' awareness regarding proper pesticide handling. Therefore, educational interventions regarding safe pesticide use, improved compliance with personal protective equipment, and monitoring of pesticide spraying practices remain essential to reduce the risk of pesticide poisoning among farmers.

#### **4. CONCLUSION**

This study concludes that both katuk leaf decoction (*Sauropus androgynus*) and breastfeeding technique education are effective in increasing breast milk production among postpartum mothers. However, katuk leaf decoction demonstrates a greater improvement compared with breastfeeding technique education when used as an active control. These findings indicate that herbal galactagogues may serve as a complementary intervention alongside lactation education in supporting optimal breastfeeding outcomes. Nevertheless, the interpretation of these results should be approached with caution due to limitations related to study design and measurement methods.

Based on these findings, katuk leaf decoction may be considered as an adjuvant intervention in postpartum care, particularly for mothers experiencing insufficient breast milk production despite receiving appropriate breastfeeding guidance, with attention to safety screening and individual response monitoring. At the policy level, the integration of locally available herbal galactagogues into breastfeeding support programs may be explored to enhance exclusive breastfeeding coverage. Further research using more rigorous designs, larger sample sizes, objective measurement methods, and longer follow-

up periods is recommended to strengthen the evidence and assess the sustainability of intervention effects.

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