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Prevalence and Associated Factors of Pesticide Poisoning among Farmers in Rural Indonesia: A Cross-Sectional Study

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Abstract
Background: *Pesticide poisoning is a significant occupational health problem among farmers in developing countries. In Indonesia, 710 cases of pesticide poisoning were reported in 2014. In Pematang Raya Village, Simalungun Regency, blood cholinesterase examinations have never been conducted due to high costs, resulting in the absence of prevalence data on pesticide poisoning.*
Method: *This study used a cross-sectional design conducted in Pematang Raya Village, Simalungun Regency, with a total sample of 43 farmers selected using purposive sampling. Blood cholinesterase levels were measured using the Lovibond method, while data on pesticide use behavior were collected through structured interviews. Data presented in frequency and proportion distributions and tested with logistic regression to identify associated factors.*
Results*: A total of 27.9% of respondents experienced pesticide poisoning. Factors significantly associated with pesticide poisoning were personal protective equipment (PPE) use ($p < 0.001$; OR = 13.50), spraying method ($p < 0.001$; OR = 13.50), and pesticide management ($p < 0.001$; OR = 90.00). In multivariable analysis, poor pesticide management remained independently associated with pesticide poisoning (aOR = 33.12; $p = 0.008$).*
Conclusion*: Reduced cholinesterase activity was observed in more than one-quarter of farmers. Poor pesticide management practices were strongly associated with pesticide poisoning. Educational interventions and behavioral changes among farmers are recommended. As a follow-up, the Smart Farmers for Pesticides Movement (GENTARIDA) was established to promote safe pesticide practices among farmers.*

Keywords*: Cholinesterase, Farmers, Pesticide poisoning, Prevalence*

INTRODUCTION

Pesticide poisoning remains a significant occupational health problem in developing countries. The World Health Organization (WHO) and the United Nations Environment Programme (UNEP) estimate 1–5 million cases of pesticide poisoning annually, with approximately 20,000 cases resulting in death.[1] Despite accounting for only a quarter of global pesticide production, developing countries experience 99% of pesticide-related deaths, attributable to intensive and unsafe use, limited regulatory enforcement, and restricted access to health and education services.[2] In Indonesia, the National Poison Information Center reported 710 cases of pesticide poisoning in 2014 caused by both intentional and unintentional exposures. [3]

Theoretically, organophosphate and carbamate pesticides inhibit cholinesterase activity, which functions to break down acetylcholine at the synaptic cleft. Inhibition of this enzyme leads to the accumulation of acetylcholine and overstimulation of the nervous system.[4] This may result in acute poisoning symptoms such as headache, nausea, and shortness of breath, as well as chronic neurological effects, including neurological disorders, muscle weakness, and cognitive decline.[5] Therefore, blood cholinesterase activity is widely used as a biomarker of pesticide exposure, with reduced levels indicating higher or prolonged exposure.[6]

Previous studies support this theoretical framework. First, a study by the Regional Environmental Impact Control Office in Pati Regency found that all vegetable farmers in Ngurensiti Village tested positive for pesticide residues in their blood, indicating long-term accumulation of exposure.[7] Second, individuals in Tomohon City reported that longer spraying duration was significantly associated with

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lower cholinesterase levels, supporting the hypothesis that repeated exposure decreases cholinesterase activity.[8] Third, in Brebes Regency, a significant association was demonstrated between the use of personal protective equipment (PPE) and cholinesterase levels among shallot farmers, supporting the theory that safe practices can reduce enzyme inhibition.[9]

A preliminary study conducted in September 2023, through interviews with officers from the Simalungun District Health Office, revealed that blood cholinesterase testing among farmers had never been conducted due to high testing costs.[10] Field observations also showed that farmers commonly used organophosphate pesticides such as curacron, proclain, and turrex, often mixed pesticides without following the recommended dosages on product labels, and sprayed at least twice a week, or even daily during the rainy season, without using PPE.[11] These findings are consistent with theoretical and empirical evidence that intensive and unsafe pesticide exposure decreases cholinesterase levels and increases the risk of poisoning.

Based on this background, the present study aimed to determine the prevalence of pesticide poisoning among farmers in Pematang Raya Village, Simalungun Regency, and to analyze factors associated with pesticide poisoning, particularly the use of PPE, spraying duration, spraying methods, and pesticide management practices.[12] This research is important because no local data are available regarding farmers' blood cholinesterase activity.[13] The findings are expected to provide scientific evidence for health authorities in designing education programs, regular health monitoring, and preventive strategies to reduce the risk of pesticide poisoning at the community level.

METHOD

Participants and Study Design

This analytical observational study employed a cross-sectional design and was conducted from September to October 2023 in Pematang Raya Village, Simalungun Regency. The study population consisted of all farmers affiliated with local farmer groups. A total of 43 pesticide sprayers were selected as participants using purposive sampling.[14]

Eligible participants were farmers aged 18–60 years who had actively engaged in pesticide spraying at least twice per week during the preceding three months, were willing to undergo laboratory examination and interviews, and provided written informed consent. Farmers with chronic diseases or those taking medications that could affect cholinesterase activity, as well as individuals who were absent during data collection, were excluded.

Measurement and Procedure

The dependent variable was pesticide poisoning status, measured based on blood cholinesterase activity. Measurements were conducted using the Lovibond method, which detects color changes corresponding to pH variations in cholinesterase enzyme activity at 12.5% intervals. Blood cholinesterase activity $<75\%$ was classified as abnormal (indicative of pesticide poisoning), while $\geq 75\%$ was classified as normal. Independent variables included the use of personal protective equipment (PPE; complete or incomplete), spraying duration (<4 hours or ≥ 4 hours per day), spraying method (correct or incorrect), and pesticide management practices (good or poor). Pesticide management was assessed based on farmers' practices related to pesticide storage, mixing, application, and disposal. Good pesticide management was defined as proper storage in designated facilities that were secure, not prone to leakage or flooding, located outside residential areas, and constructed with materials that were easy to clean. Poor pesticide management included unsafe storage, improper disposal of pesticide containers, reuse of containers for household purposes, incorrect dosage, and non-compliance with label instructions. Data on farmers' pesticide-related behaviors were obtained through structured interviews using a standardized questionnaire, while cholinesterase measurements were collected from capillary blood samples.

Statistical Analysis

Data analysis was performed in three stages. First, univariate analysis was performed to describe the distribution of each study variable using frequencies and percentages. Second, bivariate analysis was conducted using the Chi-square test to assess associations between independent variables and pesticide poisoning status, with a significance level set at $p < 0.05$. Variables meeting the inclusion criteria were subsequently entered into a multivariable logistic regression model to identify factors independently associated with pesticide poisoning.

This study received ethical approval from the Health Research Ethics Committee of Politeknik Kesehatan Kemenkes Medan, Indonesia (No. 01.240/KEPK/POLTEKKES KEMENKES MEDAN/2023). All participants were provided with information regarding the study objectives, procedures, and potential benefits, and written informed consent was obtained prior to data collection.

RESULT

Multivariable logistic regression analysis showed that pesticide management had the strongest association with decreased blood cholinesterase levels among variables examined. Poor pesticide management was significantly associated with pesticide poisoning (p=0.008; OR=33.12). Farmers with poor pesticide management practices had higher odds of experiencing decreased cholinesterase levels compared with those with good management practices.

Table 1. Characteristics of Study Participants in Pematang Raya Village, Simalungun Regency, Indonesia

Variabel	Frequency	Percentage (%)
Age (31–60 years)	43	100
Male	43	100
Education Level		
Elementary	1	2.3
Junior HS	5	11.6
Senior HS	28	65.1
Higher	9	20.9
Blood Cholinesterase Levels		
Abnormal (Indicative of Pesticide Poisoning)	12	27.9
Normal	31	72.1
PPE Use		
Incomplete	12	27.9
Complete	31	72.1
Spraying Duration		
≥ 4 Hours per day	28	65.1
< 4 Hours per day	15	34.9
Spraying method		
Poor	12	27.9
Good	31	72.1
Pesticide management		
Poor	10	23.3
Good	33	76.7

Table 1 shows the characteristics of farmers in Pematang Raya Village. All participants were aged 31–60 years (100%) and male (100%). Most have completed senior high school (65.1%), followed by higher education (20.9%), junior high school (11.6%), and elementary school (2.3%). Based on blood cholinesterase level measurements, 27.9% of farmers had abnormal levels indicative of pesticide poisoning. Regarding occupational practices, 27.9% of farmers reported incomplete use of personal protective equipment (PPE). The majority of participants (65.1%) reported spraying pesticides for ≥4 hours per day. No more than 27.9% of farmers used incorrect spraying methods (against the wind). In terms of pesticide management, 23.3% of farmers demonstrated poor practices.

Table 2 presents the association between personal protective equipment (PPE) use and blood cholinesterase levels among farmers. Among farmers with incomplete PPE use, 66.7% had abnormal blood cholinesterase levels, compared with 12.9% among those with complete PPE use. Incomplete PPE use was significantly associated with abnormal blood cholinesterase levels ($p < 0.001$), with higher odds among farmers using incomplete PPE compared with those using complete PPE (OR = 13.50).[17]

Table 2. Association between Personal Protective Equipment Use and Blood Cholinesterase Levels

PPE Use	Blood Cholinesterase Levels				Total		OR	p value
	Abnormal (Indicative of Pesticide Poisoning)		Normal					
	n	Normal (%)	n	Normal (%)	n	%		
Incomplete	8	66,7	4	33,3	12	100	13.000	0.000
Complete	4	12,9	27	87,1	31	100		

Table 3. Bivariate Associations between Spraying Duration, Spraying Method, Pesticide Management, and Blood Cholinesterase Levels

Variables	Category	Blood Cholinesterase Levels: Abnormal (Indicative of Pesticide Poisoning) n (%)	Total n (%): Normal n (%)	OR	p-value
Spraying Duration	≥ 4 hours	7 (25.0)	21 (75.0)	0.667	0.561
	< 4 hours	5 (33.3)	10 (66.7)	Ref	
Spraying Method	Incorrect	8 (66.7)	4 (33.3)	13.5	0.000
	Correct	4 (12.9)	27 (87.1)	Ref	
Pesticide Management	Poor	9 (90.0)	1 (10.0)	90.0	0.000
	Good	3 (9.1)	30 (90.9)	Ref	

Table 3 presents the bivariate associations between spraying duration, spraying method, pesticide management, and blood cholinesterase levels among farmers. Of the 43 respondents, 27.9% exhibited decreased cholinesterase levels, while 72.1% had normal levels. Spraying duration was not significantly associated with cholinesterase levels ($p = 0.561$; OR = 0.667), as farmers spraying for ≥ 4 hours showed a comparable proportion of abnormal cholinesterase levels (25.0%) to those spraying for < 4 hours (33.3%). In contrast, the spraying method and pesticide management demonstrated statistically significant associations with blood cholinesterase levels. Farmers who used an incorrect spraying method (against the wind) had a higher proportion of abnormal cholinesterase levels (66.7%) compared with those using a correct method (spraying with the wind; 12.9%), with significantly higher odds observed (OR = 13.50; $p < 0.001$). Similarly, poor pesticide management was significantly associated with a markedly higher proportion of abnormal cholinesterase levels (90.0%) compared with good management practices (9.1%). This variable showed the highest magnitude of association, with substantially higher odds of abnormal cholinesterase levels (OR = 90.00; $p < 0.001$).

These findings suggest that behavioral and management-related factors play a more critical role in cholinesterase inhibition than exposure duration alone. Improper spraying practices, particularly spraying against the wind, likely increase direct pesticide exposure through inhalation and dermal contact, thereby elevating the risk of cholinesterase inhibition. Moreover, the exceptionally high odds associated with poor pesticide management indicate that unsafe handling, storage, mixing procedures, and inadequate use of personal protective equipment substantially contribute to pesticide poisoning. Based on the bivariate analysis, variables with p-values <0.25, including spraying method and pesticide management, were subsequently entered into the multivariate logistic regression model to control for potential confounding. After applying the backward stepwise likelihood ratio method, pesticide management emerged as the only variable independently associated with decreased cholinesterase levels ($p = 0.008$), underscoring its dominant role as a key determinant of pesticide-related health risk among farmers.

The initial model suggested that PPE use, spraying method, and pesticide management jointly influence cholinesterase activity. However, after controlling for other variables in the final stepwise model, only pesticide management remained strongly and independently associated. The coefficient (β) of 3.500 with an OR of 33.124 indicates that poor pesticide management increased the risk of poisoning by approximately 33 times compared to good management practices.

Table 4. Multivariable Logistic Regression Model of Factors Associated with Blood Cholinesterase Level among Farmers in Pematang Raya Village

Variables	B	aOR	p-value	95 % CI	
				Lower	Upper
PPE Use	1.780	5.929	0.132	0.584	60.228
Spraying Method	1.780	5.929	0.132	0.584	60.228
Pesticide Management	3.500	33.124	0.008	2.470	444.120

DISCUSSION

Characteristics of Respondents

Although all respondents in this study were male farmers aged 31–60 years. Farmers aged over 45 years were found to be more vulnerable to pesticide poisoning because the body's resistance to toxins decreases with age. Similarly, cholinesterase enzyme activity also declines, thereby increasing susceptibility to pesticide exposure.[19] Regarding education, the majority of respondents had completed senior high school (65.1%), while 20.9% had completed higher education. Education level may influence farmers' knowledge and attitudes toward pesticide use. Higher educational attainment is often associated with better cognitive ability to process and apply information related to safe pesticide practices.[20] This observation is consistent with theoretical perspectives suggesting that education and farming experience influence decision-making, including pesticide application practices. [21]

Cholinesterase Levels

The results showed that 27.9% of respondents experienced poisoning characterized by reduced cholinesterase activity. Cholinesterase is widely recognized as a biomarker of pesticide exposure, as certain pesticides bind to the enzyme and inhibit its activity. Inhibition of cholinesterase disrupts nerve impulse transmission and may result in clinical manifestations of poisoning such as muscle spasms, blurred vision, excessive salivation, and respiratory failure.[22] This finding supports the theoretical framework that decreased cholinesterase activity indicates pesticide exposure.

Personal Protective Equipment (PPE) Use and Pesticide Poisoning

Bivariate analysis revealed a significant association between completeness of personal protective equipment (PPE) and pesticide poisoning ($p < 0.001$; OR = 13.50). This magnitude of association indicates that farmers who used incomplete PPE had approximately 13.5 times higher odds of pesticide poisoning compared with those who used complete PPE. This finding is consistent with occupational health theory, which emphasizes PPE as an essential barrier against pesticide absorption through inhalation, skin, and digestion. Previous studies have also confirmed that the completeness of PPE is significantly associated with reduced risk of pesticide poisoning.[23]

Spraying Duration and Pesticide Poisoning

The analysis showed no statistically significant association between spraying duration and pesticide poisoning ($p = 0.561$; OR = 0.667). This finding does not fully align with the theoretical expectation that longer exposure time may be associated with greater accumulation of toxicity. One possible explanation is the compensatory mechanism of cholinesterase recovery, whereby enzyme activity may return to normal within 2–3 weeks without further exposure.[24] Additionally, variations in farmland size and farmers' resting patterns may have reduced the cumulative effect of exposure. Thus, spraying duration alone may not be associated with pesticide poisoning in this study.[25]

Spraying Method and Pesticide Poisoning

There was a significant association between spraying method and pesticide poisoning ($p < 0.001$; OR = 13.50). This magnitude suggests that farmers who sprayed against the wind (an incorrect method) had 13.50 times higher odds of pesticide poisoning compared with those who sprayed in the direction of the wind (a correct method). This finding is consistent with environmental exposure theory, which states that wind direction influences the dispersion of airborne pesticide particles. A similar finding has been reported by Utami et al., who demonstrated that improper spraying techniques may increase exposure through inhalation and dermal contact.[26]

Pesticide Management and Pesticide Poisoning

Multivariable analysis identified pesticide management as the factor most strongly associated with pesticide poisoning (p = 0.008; aOR = 33.12). In other words, farmers with poor pesticide management practices, such as improper storage, reuse of pesticide containers for household purposes, incorrect dosing, and unsafe disposal, had 33 times higher odds of pesticide poisoning compared with those who practiced good pesticide management. This finding supports behavioral health theory, which suggests that inadequate knowledge and unsafe practices may increase the risk of pesticide exposure.[27] finding is also consistent with a study by Widiastuty et al. that reported a significant association between pesticide management and cholinesterase activity among farmers.[28] Therefore, proper pesticide management appears to be an important factor in preventing pesticide poisoning.

This study used a cross-sectional design, which limits the ability to infer causal relationships between pesticide management practices and poisoning incidence. Additionally, the sample size was relatively small and limited to a single village, potentially limiting the generalizability of the findings to other agricultural populations. Self-reported data on pesticide handling behaviors may also be subject to recall bias or social desirability bias. Future studies with longitudinal designs and larger sample sizes are recommended to validate these findings and explore long-term health effects. The OR interval in this study spans a wide range from 2.470 to 444.124. This indicates that the results are not precise due to limitations in the research design, and the risk value is overestimated, as the actual risk in a cross-sectional design is PR (Prevalence Ratio), whereas in this study it is OR.

CONCLUSION

This study, conducted in Pematang Raya Village, Simalungun Regency, concluded that pesticide poisoning remains a significant health problem among farmers, with 27.9% of respondents experiencing decreased blood cholinesterase levels. Factors associated with pesticide poisoning were incomplete use of personal protective equipment (PPE), incorrect spraying method, and poor pesticide management practices, such as improper storage, mixing, and disposal. In contrast, spraying duration was not significantly associated with pesticide poisoning. These findings highlight the urgent need for educational interventions and behavioral changes among farmers to ensure appropriate PPE use, safe spraying methods, and proper pesticide management. As a follow-up, the establishment of the Smart Farmers Movement for Pesticide Safety program or GENTARIDA, supported by an official decree issued by the village head, may serve as a strategic step to reduce pesticide-related health risks, enhance farmers' knowledge, and strengthen safe pesticide practices at the community level.

ETHICS APPROVAL

This study received ethical approval (No. 01.240/KEPK/POLTEKKES KEMENKES MEDAN/2023).

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COMPETING INTEREST

All authors declare that there are no conflicts of interest.

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UNDERLYING DATA

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

DECLARATION OF ARTIFICIAL INTELLIGENCE USE

We confirm that there is no artificial intelligence (AI) used at any stage of the study, including data collection, analysis, visualization, etc. All work in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

REFERENCES

1. Achmadi UF. Manajemen penyakit berbasis wilayah. *Kesmas*. 2009;3(4):147-153.
2. Alhumaira AF. Analisis Pengaruh Paparan Karbofuran Dan Karakteristik Pekerja Terhadap Aktivitas Enzim Cholinesterase Pada Pekerja Area Produksi Butiran Di Pt. X. Published online 2017.
3. Marisa M, Arrasyid AS. Pemeriksaan kadar pestisida dalam darah petani bawang merah di Nagari Alahan Panjang. *Sainstek J Sains dan Teknol*. 2018;9(1):14-18.
4. Reeves WR, McGuire MK, Stokes M, Vicini JL. Assessing the safety of pesticides in food: How current regulations protect human health. *Adv Nutr*. 2019;10(1):80-88.
5. Budiawan AR. Faktor risiko yang berhubungan dengan cholinesterase pada petani bawang merah di Ngurensiti Pati. *Unnes J Public Heal*. 2014;3(1).
6. Caro-Gamboa LJ, Forero-Castro M, Dallo-Báez AE. Cholinesterase inhibition as a biomarker for the surveillance of the occupational population exposed to organophosphorus pesticides. *Rev Cienc y Tecnol Agropecu*. 2020;21(3).
7. Susilowati DA, Suhartono S, Widjanarko B. Faktor Pengetahuan dan Perilaku Petani Penyemprot yang Berhubungan dengan Kadar Serum Cholinesterase di Kabupaten Brebes. *J Epidemiol Kesehat Komunitas*. 2018;3(2):63-67.
8. Organization WH. *International Code of Conduct on Pesticide Management. Guidance on Use of Pesticide Regulation to Prevent Suicide*. World Health Organization; 2023.
9. Hermawan I, Widjasena B, Kurniawan B. Faktor-faktor yang berhubungan dengan aktivitas kolinesterase darah pada petani jambu di Desa Pesaren Kecamatan Sukorejo Kabupaten Kendal. *J Kesehat Masy*. 2018;6(4):309-320.
10. Denny HM. Pedoman Penggunaan Pestisida Secara Aman dan Sehat di Tempat Kerja Sektor Pertanian (Bagi Petugas Kesehatan).
11. Damanik SD. Tanah dan Urbanisasi di Pematang Raya (Studi Kasus Tentang Kehadiran Orang Baru dan Tersingkirnya Penduduk Lokal Etnis Simalungun di Pematang Raya Kabupaten Simalungun). Published online 2018.
12. Fajriani GN. Hubungan intensitas penyemprotan pestisida dengan kadar kolinesterase dalam darah petani di Desa Pasirhalang Kabupaten Bandung Barat. *Meditory J Med Lab*. 2019;7(2).
13. Fitriana F, Suhartono S, Darundiati YH. Studi Prevalensi Kejadian Keracunan Pestisida Pada Petani Penyemprot Bawang Merah Desa Karang Tengah Kecamatan Bagor Kabupaten Nganjuk. Published online 2019.
14. Hanson WE, Plano Clark VL, Petska KS, Creswell JW, Creswell JD. Mixed methods research designs in counseling psychology. *J Couns Psychol*. 2005;52(2):224-235. doi:10.1037/0022-0167.52.2.224
15. Hayat AMF, Nurazizah W, Noviponiharwani N, Rahman SF, Sunu B. Hubungan pengetahuan dan sikap petani dengan pemakaian alat pelindung diri (APD) saat penyemprotan pestisida. *Prepotif J Kesehat Masy*. 2023;7(3):16278-16285.
16. Sari NKM, Mastra N, Habibah N. Gambaran Kadar Enzim Kolinesterase Dalam Darah Pada Kelompok Tani Mekar Nadi Di Desa Batunya Kecamatan Baturiti. *Meditory J Med Lab*. 2019;6(2):108-115.
17. Matthews GA. *Pesticides: Health, Safety and the Environment*. John Wiley & Sons; 2015.
18. Khalishah I, Saftarina F, Pardilawati CY. Penggunaan APD pada Petani yang Menggunakan Pestisida ditinjau dari Aspek Health Belief Model. *J Kesehat dan Agromedicine*. 2023;10(1):86-92.
19. Mokoagow D, Joseph WBS, Patras HD. Hubungan Antara Masa Kerja, Pengelolaan Pestisida Dan Lama Penyemprotan Dengan Kadar Kolinesterase Darah Pada Petani Sayur Di Kelurahan Rurukan Kecamatan Tomohon Timur Kota Tomohon.
20. NOLIA R TAMBUNAN H, Rusli M, Sembiring H, Bariyah K. Peningkatan Pengetahuan dan Keterampilan Petani Dalam Penggunaan APD Untuk Pencegahan dan Penanggulangan Kejadian Keracunan Pestisida di Desa Barusjahe Kecamatan Barusjahe Tahun 2020. Published online 2021.
21. Jepson PC, Murray K, Bach O, Bonilla MA, Neumeister L. Selection of pesticides to reduce human and environmental health risks: a global guideline and minimum pesticides list. *Lancet Planet Heal*. 2020;4(2):e56-e63.

22. Rahim MR, Russeng SS, Tampudu S. Gambaran Kadar Cholinesterase Darah Petani Penyemprot Pestisida di Desa Minasa Baji Kab. maros. *Media Kesehat Masy Indones Univ Hasanuddin*. 2010;6(2):27378.
23. Fargnoli M, Lombardi M, Puri D, et al. The safe use of pesticides: a risk assessment procedure for the enhancement of occupational health and safety (OHS) management. *Int J Environ Res Public Health*. 2019;16(3):310.
24. Tallo YT, Littik SKA, Doke S. Gambaran Perilaku Petani dalam Penggunaan Pestisida dan Alat Pelindung Diri terhadap Keluhan Kesehatan Petani di Desa Netenaen Kabupaten Rote Ndao. *J Pangan Gizi Dan Kesehat*. 2022;11(1):64-80.
25. Yuantari MGC, Trya CN. Analisis Faktor Risiko Kejadian Keracunan Pestisida Anorganik Pada Enzim Cholinesterase Dalam Darah Petani. *VISIKES J Kesehat Masy*. 2020;19(2).
26. Utami TP, Lestari M, Novrikasari N, et al. Penurunan Kadar Enzim Kolinesterase Tenaga Sprayer di Perkebunan Kelapa Sawit. *J Kesehat Lingkung Indones*. 2021;20(1):27-33.
27. Wisnujatia NS, Sangadji SS. Pengelolaan penggunaan pestisida dalam mendukung pembangunan berkelanjutan di indonesia. *SEPA J Sos Ekon Pertan dan Agribisnis*. 2021;18(1):92-100.
28. Widiastuty L, Ekasari R, Ibrahim IA, Karini TA, Adnan Y, Azwar M. Keracunan Pestisida Pada Petani Bawang Merah di Desa Pasui Kecamatan Buntu Batu Kabupaten Enrekang. *Hig J Kesehat Lingkung*. 2022;8(1):47-54.