Original Article

Blood Cholinesterase Depression of Pesticide Handlers at Oil Palm Plantations

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ABSTRACT: *Malaysia's oil palm industry boosts the economy as the second largest producer in the world. In an effort to control pests and ensure adequate supply, a wide variety of pesticides are used, despite they may pose various health risks due to the toxicity, absorption and reaction in the body. The goal of this study was to determine the potential exposures of pesticides to oil plantation workers via observations and questionnaires as well as to investigate exposure pesticides by assessing the blood cholinesterase depression of the pesticide handlers. A cross-sectional study was conducted on 109 pesticide handlers of 15 small and big plantations, by collecting their fingerprick blood samples, analyzed for cholinesterase level pre- and post-exposure. Reductions of ≥ 25% were considered evidence of meaningful cholinesterase depression. The workers were also observed while performing their tasks for potential exposure. Findings showed that 28% of the pesticide handlers had exposure of various levels, with most of them (40%) were those working in small plantations. Big plantations indicated exposure at normal cholinesterase levels, about 80% of the participants required no action. Meanwhile, 6% indicated very serious overexposure and serious overexposure that may require the workers to be suspended or removed from the tasks, in order to avoid further health effects. Protective measures, such as providing proper personal protective equipment, ensuring adherence to safety protocols, and regular health monitoring, are essential to safeguard the health and well-being of pesticide handlers. Besides, training on safe operating procedures and work practices may be useful to minimize or avoid exposure. Proactive measures can significantly reduce the incidence of overexposure and protect the health of pesticide handlers, ensuring sustainable and safe agricultural practices.*

Keywords: *Blood, Cholinesterase, Dermal Exposure, Oil Palm Plantation, Pesticides*

1.0 INTRODUCTION

In the realm of agriculture, the strategic use of pesticides is indispensable for pest management and safeguarding crops. However, this agricultural necessity comes with an inherent challenge: the potential health risks faced by those actively engaged in the application and mixing of these essential chemicals. Pesticide exposure poses a considerable threat to human well-being, impacting an alarming estimate of three million individuals globally each year (Tudi et al., 2022). The Pesticide Action Network Asia Pacific (PANAP) revealed that most pesticides being used in selected farming communities are considered highly hazardous and can harm human health and the environment, which are banned in one or more Asian countries. Based on the 2022 PAN International Consolidated List of Banned Pesticides, it was found that 27 out of the 36 pesticides employed, accounting for 75%, were categorized as highly hazardous. Additionally, a significant 81% of these pesticides were prohibited in one or more countries, with 69% banned specifically in the European Union. According to Boedeker et al., (2020), approximately 385 million farmers and workers are poisoned by pesticides every year, including around 11,000 fatalities, which is 44% of farmers and farmworkers poisoned each year, with that figure rising to 51% in Southeast Asia and 65% in South Asia. Despite the adverse health effects documented, the pesticide is still needed in the oil palm plantation industry.

Pesticide applications are frequently counterproductive, as they unintentionally eliminate beneficial species, promote the development of pest resistance, and expose end gaps in users' knowledge about associated risks, such as the importance of correct application and necessary precautions (Damalas & Eleftherohorinos, 2011). Despite farmers' understanding of pesticide hazards, the problem is turning this information into appropriate practices, as noted by (Palis et al., 2006), who discovered a widespread belief among farmers in their resilience to pesticide impacts. Furthermore, farmers tend to underestimate dermal exposure risks while neglecting the hazards of inhalation and ingestion. Inadequate regulation, poor surveillance systems, and unsafe handling practices contribute to the risks faced by small-scale plantation workers(Quandt et al., 2010). The primary objectives of this research encompass:

i. To determine the potential exposures of pesticides to oil palm plantation workers via observations and questionnaires
ii. To measure the blood cholinesterase depression of oil plantation workers via assessing the acetylcholinesterase (AChE) activity.

The study employs a comprehensive approach, delineating specific aims to deepen our comprehension of the intricacies surrounding pesticide handling. Its focus is on identifying potential routes of cross-contamination in pesticide application and elucidating the nuanced impacts of pesticide exposure on the health of laborers engaged in these activities. Notably, the cholinesterase levels before and after sampling are anticipated to exhibit disparities due to direct pesticide exposure during all processes undertaken by the workers (Quandr et al., 2010).

This investigation is particularly situated in the distinctive context of oil palm plantations, providing insights directly applicable to this specific agricultural environment. While acknowledging the undeniable benefits of pesticides, such as increased productivity and improved crop quality, the study emphasizes the imperative of addressing potential adverse effects on human health. Its significance lies in contributing to a broader discourse by educating diverse stakeholders, including the public and both employees and employers, on the critical importance of adopting sound work practices and adhering to established standard operating procedures and guidelines. Recognizing that the implementation of rigorous safety protocols and adherence to guidelines are linchpins in reducing occupational illnesses among workers (Kirkhorn & Schenker, 2002), the study highlights the critical need for such measures in the realm of pesticide handling. By addressing these components within the specific framework of blood cholinesterase depression among pesticide handlers at oil palm plantations, this research aims not only to contribute valuable insights but also to catalyze practical improvements in work practices, ensuring a healthier and more sustainable future for those on the frontline of agricultural productivity.

2.0 METHODS

2.1 Research Methods

2.1.1 Sample Size

Our study consisted of 109 subjects that were determined using the Krejcie-Morgan sampling technique, which is based on simple random sampling principles. Using a cross-sectional design, we employ a purposive sampling approach focusing on plantations that only use pesticides. The sample size formula for calculating sample size (n) and margin of error (E) includes variables such as population size (N), the fraction of interest responses (r), and the critical value (Z) that corresponds to the desired confidence level (c). The first equation, referred to as "equation 1," describes the calculation process.

$$x = Z(^{c}/_{100})^2 r(100-r)$$

$$n = {}^{N x}/_{((N-1)E^2 + x)}$$

$$E = \mathrm{Sqrt}[^{(N-n)x}/_{n(N-1)}] \qquad (1)$$

2.1.2 Study Population

The study involves participants from the agricultural sector, specifically targeting workers who handle pesticides in oil palm plantations. It involves selected small and big oil palm plantations in a few states in Malaysia (Sabah, Kedah, Johor, Terengganu, and Pahang). The inclusion criteria include:

i. Registered workers in oil palm plantations.
ii. Involved in pesticide handling.
iii. Aged between 18 and 60 years old.

The exclusion criteria are:

i. Workers are on medication.
ii. Have any chronic diseases.
iii. Less than six months of experience.
iv. Workers exposed to organic solvents.

The study includes who are, regardless of their nationality, meaning both Malaysian citizens and non-citizens are eligible. However, these participants must ensure that health variables are controlled. Additionally, they must give verbal and written consent to participate in the study, confirming their understanding and willingness. On the other hand, the study excludes workers who are on medication or suffering from chronic diseases, as these conditions could potentially interfere with the study results. Those who wish to withdraw from the study are also excluded to respect their autonomy. Workers with less than six months of experience handling pesticides are ruled out to ensure that the participants have a significant level of exposure. Similarly, workers exposed to organic solvents but not specifically to pesticides are excluded to maintain the focus on pesticide exposure. Lastly, any workers diagnosed as unhealthy by a physician during the sampling or data collection period are also excluded to protect their well-being.

2.1.3 Data Collection

Data collection methods include (i) observations, (ii) questionnaires, and (iii) cholinesterase level measurements. Observations are conducted to assess work behaviors and environmental factors that may contribute to pesticide exposure. Questionnaires are utilized to gather information on work practices, including the use of personal protective equipment (PPE), adherence to safety protocols, and training programs. Cholinesterase levels were measured to determine the extent of inhibition, with higher inhibition indicating higher pesticide exposure. It revealed a spectrum of pesticide exposure levels among oil palm plantation workers, ranging from severe overexposure to minimal or no exposure, as indicated by cholinesterase levels. Our data collection methodology encompasses a comprehensive approach, employing multiple techniques to garner a nuanced understanding of the factors influencing cholinesterase levels.

2.2 Observational

This assessment involved visual observations of workers, carried out at a reasonable distance to minimize interference with their tasks. Several aspects of the workers' activities were scrutinized to identify potential exposure factors, including the type of pesticides used, frequencies of handling pesticides, the methods employed in preparing, and mixing, the duration of pesticide handling, and the utilization of personal protective equipment (PPE). Furthermore, this study observed workers' behaviors, such as techniques for wearing and removing gloves, as well as personal habits relevant to pesticide exposure. To ensure consistency and reproducibility of the collected data, these aspects were employed by the researchers during the observation study.

2.3 Questionnaires

To enhance our comprehension of the wider context, we utilize qualitative data collection techniques in addition to the quantitative data obtained from cholinesterase measurements. Questionnaires are utilized to gather information on various work practices, encompassing elements such as the consistent use of personal protective equipment (PPE), adherence to safety protocols, and participation in training programs (Botinggo et al., 2021; Udin et al., 2019). This multifaceted approach allows us to explore the interplay of individual behaviors and institutional factors that may contribute to varying levels of pesticide exposure among workers.

Furthermore, our study incorporates observational methods to provide a real-time assessment of work behaviors and environmental factors within the unique setting of oil palm plantations. By keenly observing and documenting practices on-site, we aim to uncover nuanced aspects of pesticide handling that may not be captured through self-reporting alone. This holistic approach ensures a comprehensive exploration of the complex dynamics influencing pesticide exposure.

2.4 Blood Cholinesterase Study

Cholinesterase level measurements serve as a core component of the quantitative analysis to gauge the extent of inhibition (Suratno et al., 2018). The level of pesticide exposure was analyzed using the Lovibond AF267 Cholinesterase Test Kit. A higher level of inhibition is indicative of heightened pesticide exposure, providing crucial insights into the potential health risks faced by workers (Sheikh et al., 2011). This objective, measurable marker is instrumental in establishing a direct correlation between pesticide handling and its physiological impact. The principle of the cholinesterase test is based on the measurement of cholinesterase enzyme activity in the blood to assess pesticide exposure. Blood cholinesterase activity refers to the quantity of active cholinesterase enzymes present in blood plasma and red blood cells, which contribute to the regulation of the nervous system's stability. (Daulay et al., 2020).

Cholinesterase is an enzyme that breaks down acetylcholine, resulting in the release of acetic acid and a change in pH. In the test, a mixture of blood, indicator, and acetylcholine perchlorate is prepared and allowed to stand for a fixed time. For the blood sampling and pipetting process in the test, a test tube containing the indicator solution is prepared as the "control." The area of skin on the thumb or finger is washed, dried, and cleaned using a disposable alcohol swab. A disposable lancet is used for each blood sample. The sample area is pricked to produce a large droplet of blood (approximately 10 µl). To pipette the blood, the yellow push button of the pipette is pressed to the first stop. To discharge the blood sample, the pipette tip is placed inside the test tube containing the indicator solution, with the tip below the surface of the solution, and the button is pushed down to release the sample. This process ensures that a controlled amount of blood is collected and transferred for further analysis in the cholinesterase test. The color of the mixture is then compared to a control sample to measure the change in pH, which serves as an indicator of cholinesterase activity in the blood. By analyzing the level of cholinesterase activity, the test can determine if an individual has normal cholinesterase activity, overexposure to pesticides, or serious overexposure (Angbo Yapo et al., 2017).

According to the manufacturer's manual for the test kit, Cholinesterase activity levels are categorised into four principal ranges, each indicating different levels of pesticide exposure severity:

1. **Normal**: This range encompasses 100% to 75% of standard cholinesterase activity. If a worker's cholinesterase activity is within this range, it indicates that no urgent intervention is necessary; nonetheless, a subsequent retest is advisable to assess the condition.

2. **Probable Overexposure**: Cholinesterase activity ranging from 75% to 50% of normal signifies likely pesticide overexposure. In such instances, the test must be reiterated, and if the results are validated, the individual should be provisionally removed from employment using pesticides for a duration of two weeks, after which a retest should be conducted to evaluate recovery.

3. **Serious Overexposure**: A cholinesterase activity level ranging from 50% to 25% of normal signifies severe overexposure. The test must be reiterated, and if validated, the subject should be prohibited from all activities involving insecticides. A medical evaluation is advised to evaluate the person's health and ascertain further actions.

4. **Very Serious Overexposure**: The most critical category is severe overexposure, characterised by cholinesterase activity ranging from 25% to 0% of normal levels. In such instances, the test must be promptly repeated, and if validated, the individual should be suspended from all duties for a medical evaluation. The suggested measures are intended to safeguard the health and safety of the tested individuals.

The study's results indicate that a considerable proportion of workers have differing degrees of cholinesterase inhibition, with a large percentage exhibiting probable, serious, or very serious overexposure. The results highlight the significance of routine health monitoring, appropriate use of personal protective equipment (PPE), compliance with safety standards, and thorough training programs to reduce the hazards linked to pesticide exposure in the oil palm plantation sector (Daulay et al., 2020).

Based on the test results, the document provides tailored recommendations and actions for each test subject. The recommendations may involve extra medical examination, changes in pesticide handling practices, or the implementation of additional protective measures. The specific actions recommended depend on the interpretation of the data and the degree of cholinesterase inhibition or pesticide exposure indicated by the test results.

If the cholinesterase activity is within the range of 100% to 75% of normal, no immediate action is required, but a retest in the near future is recommended. For cholinesterase activity between 75% and 50% of normal, overexposure is probable, and the test should be repeated. If confirmed, the individual should be suspended from further work with organic phosphorus insecticides for two weeks, followed by a retest to assess recovery.

In cases where cholinesterase activity is between 50% and 25% of normal, serious overexposure is indicated. The test should be repeated, and if confirmed, the individual should be suspended from all work with insecticides. A medical examination is recommended in these cases.

The recommended actions are based on the specific results received and are aimed at protecting the health and safety of the individuals tested. It is important to follow these recommendations to minimize the risks associated with pesticide exposure. In essence, our meticulous methodology integrates quantitative and qualitative data collection methods, utilizing cholinesterase measurements, questionnaires, and observations to offer a robust understanding of pesticide exposure among workers at oil palm plantations. This nuanced examination contributes to a more informed and actionable comprehension of the factors influencing blood cholinesterase depression in the specific context of pesticide handlers in the oil palm industry.

3.0 RESULTS AND DISCUSSION

3.1 Socio-demographic

The study included participants in various age groups (18-52 years old), with a majority of male participants are pesticide sprayer workers at oil palm plantations, a high-risk and demanding job (Ramdan et al., 2020). The age of the workers was included to indicate the accumulation of time exposure and the response of body organs to pesticide exposure. In this study, male respondents were identified as dominated by foreigners from Pakistan and Indians with a minority of 20.6% are Malaysians and Indonesians. Elmhirst et al., (2017) have outlined that international norms and functional considerations often lead to a preference for male workers in oil palm plantations. This aligns with the goals of boosting yield while simultaneously mitigating occupational health concerns.

Agricultural sectors in Malaysia rely on a significant number of foreign workers due to their work capacities, cost-effectiveness, and human resource issues. Consequently, a higher proportion of workers aged 26-45 years old have fulfilled the occupational needs of pesticide sprayers in the agricultural industry, particularly in oil palm farms. This line of work demands working in extreme weather that requires a high level of physical endurance. Furthermore, those working in this industry must not have any pre-existing health concerns, as the risk from pesticide-related illness is also increased. Based on observation, an increased cholinesterase level within the range indicating probable overexposure (50% to 74%) is connected to several reasons. Among these factors, a high incidence of smoking among workers (67%) as a potential contributor to increased risk, worsened by poor pesticide post-handling hygiene practices (Rabi et al., 2021). This study found that 80% of the respondents were smokers and 86% respondents were involved in spraying pesticide activity on daily basis. The data hint that these workers were potentially exposed to pesticide. Table 1.0 illustrates the distribution of sociodemographic characteristics of the respondents.

Table 1.0 Socio-Demographic Information of the Respondents, n=109

Variables	n=109	Percentage / %
Age (years)		
16-25	26	24
26-35	42	38
36-45	36	33
46-55	5	5
Working Experience (Month)		
< 5 months	46	42
6-12 months	26	24
>12 months	37	34
Smoking Status		
Yes	87	80
No	22	20

Cross-contamination of pesticide exposure among oil palm workers occurs when their body parts come into contact with equipment, machinery or transportation contaminated with pesticides (Udin et al., 2021). In this study, we observe the exposure mostly happens during donning PPE, doofing the glove during breaks, touching other contaminated surfaces, loading diluted pesticides into knapsack sprayer, and other job tasks that require workers to directly handle pesticides (Botinggo et al., 2021).

3.2 Observational Results

There are two aspects of visual observations of workers, carried out by identifying the type of pesticides used, frequency of pesticides handling. Table 2.0 presents the type of pesticide used and the frequency of pesticides handling among the workers. The most type of pesticides used was herbicide (73%), followed by insecticide (24%) and rodenticide (5%). For the frequency of usage, 86% respondents said they used on daily basis, while 11% said they use twice a week and 3% mentioned the usage of twice a month. This study observed the usage of high chemical herbicide is mostly used in both small and big plantations due to the effectiveness of this substances in remove and kill the weeds compared to insecticide and rodenticide. Perhaps the potential exposure also associates with the frequency of spraying pesticide as a daily activity in both plantations.

Table 2.0 The Type of Pesticide Used and the Frequency of Usage

Variables	(n=109)	Percentage / %
Type of pesticide used.		
Herbicide	80	73
Insecticide	24	22
Rodenticide	5	5
Frequency of spraying pesticide		
Everyday	94	86
Twice a week	12	11
Twice a month	3	3

3.3 Questionnaires Results

Data was collected from all workers who volunteered to participate in this study through active survey and included in the research's questionnaire. The questionnaire was adopted from Botinggo et al. (2021) and Udin et al. (2019). Out of 109 workers, 32 of them were from small plantation and 77 from big plantation. A total of 30 questions are used as an observational tool while worker handling the pesticides to explore potential exposures of pesticides to oil palm plantation workers. Most workers in big plantation practicing good hygiene compared to the workers in small plantation. Table 3.0 displays the observation questionnaire percentage data.

There are significant differences in the adherence to safety standards. Within the Small Plantation (n=32), there is a significant presence of hazardous actions, including smoking (28.13%), eating (84.38%), and drinking (62.50%) while handling pesticides. Although there is a high level of compliance in removing and storing personal protective equipment (PPE) during rest time, there is a lack of adherence to washing and storing PPE after use. The percentages for washing goggles, gloves, masks, and aprons are low, with just 37.50% for goggles, 65.63% for gloves, 43.75% for masks, and 31.25% for aprons. Workers demonstrate a moderate level of compliance with handwashing after removing Personal Protective Equipment (PPE) at a rate of 53.13%, and with using soap at a rate of 56.25%.

On the other side, the Big Plantation (n=77) exhibits superior safety measures, as seen by a lower percentage of handlers engaging in smoking (12.99%) or eating (2.60%) while handling pesticides. The level of compliance with the removal and storage of personal protective equipment (PPE) during rest periods is strong, and there is a commendable commitment to the practice of washing and storing PPE after use. Workers demonstrate a significant level of adherence to handwashing protocols after removing personal protective equipment (96.88%) and using soap (93.51%). These findings suggest that there is a requirement for enhanced safety training and enforcement, particularly in the Small Plantation area.

Table 3.0 Observation questionnaire percentage summary (n=109)

Number	Variable	Small Plantation, n=32 (%)			Big Plantation, n=77 (%)		
		Yes	No	Sometimes	Yes	No	Sometimes
1	Smoking during pesticides handling	28.13	53.13	18.75	12.99	80.52	6.49
2	Eat during pesticides handling	84.38	12.50	3.13	2.60	90.91	6.49
3	Drink during pesticides handling	62.50	12.50	25.00	89.61	2.60	7.79
4	Using mobile phone	93.75	0.00	6.25	0.00	97.40	2.60
5	Touch any body parts	87.50	3.13	9.38	100.00	0.00	0.00
6	Sit near the pesticides refill containers during rest time.	90.63	0.00	9.38	7.79	75.32	16.88
7	Take-off mask during rest time and put it and the proper place.	100.00	0.00	0.00	100.00	0.00	0.00
8	Take-off gloves during rest time and put it and the proper place.	100.00	0.00	0.00	100.00	0.00	0.00
9	Take-off goggles during rest time and put it and the proper place	100.00	0.00	0.00	100.00	0.00	0.00
10	Take-off apron during rest time and put it and the proper place.	100.00	0.00	0.00	100.00	0.00	0.00

11	Joke around with other pesticides handlers during working.	0.00	100.00	0.00	0.00	100.00	0.00
12	Ask for a new filter immediately if it already broken or dirty.	46.88	0.00	53.13	70.13	0.00	29.87
13	Ask for a new apron immediately if it already broken or dirty.	87.50	0.00	12.50	93.51	0.00	6.49
14	Ask for a new pair of boots immediately if it already broken or dirty.	100.00	0.00	0.00	89.61	0.00	10.39
15	Follow labelled instruction during premix.	53.13	31.25	15.63	92.21	2.60	5.19
16	Spraying against the wind direction.	65.63	0.00	34.38	77.92	2.60	19.48
17	Wash goggle after used.	43.75	18.75	37.50	89.61	3.90	6.49
18	Store goggles properly after used at the provided room.	31.25	59.38	9.38	83.12	2.60	14.29
19	Wash gloves after used.	18.75	56.25	25.00	92.21	0.00	7.79
20	Store gloves properly after used at the provided room	37.50	46.88	15.63	76.62	6.49	16.88
21	Wash mask after used	0.00	96.88	3.13	0.00	97.40	2.60
22	Store mask properly after used at the provided room	87.50	0.00	12.50	100.00	0.00	0.00
23	Store headwear properly after used at the provided room.	84.38	6.25	9.38	100.00	0.00	0.00
24	Wash apron after used	37.50	59.38	3.13	31.17	61.04	7.79
25	Store apron properly after used at the provided room	62.50	25.00	12.50	100.00	0.00	0.00
26	Wash rubber boots after used.	93.75	0.00	6.25	100.00	0.00	0.00
27	Wash hands after remove all PPE.	100.00	0.00	0.00	100.00	0.00	0.00
28	Wash hands with soap	100.00	0.00	0.00	100.00	0.00	0.00
29	Get shower at the provided washroom.	81.25	6.25	12.50	15.58	80.52	3.90
30	Wash clothes at the provided washing area.	18.75	75.00	6.25	87.01	5.19	7.79

3.4 Cholinesterase Levels of the Pesticide Handlers

The cholinesterase test used the enzyme's activity in the blood to determine pesticide exposure. The test involved measuring the level of cholinesterase activity, which breaks down acetylcholine and causes a pH change. The Lovibond AF267 Cholinesterase Test Kit was used in the analysis. The test measured pH changes to determine cholinesterase activity in the blood, which serves as an indicator of pesticide exposure. The test results were interpreted according to the level of cholinesterase activity, with higher inhibition indicating increased pesticide exposure. The results were classified as normal, probable overexposure, serious overexposure, and very serious overexposure based on the percentage of cholinesterase activity relative to normal levels. Specific actions and recommendations were then tailored for each test subject based on the results of their cholinesterase level tests, with the goal of protecting the individuals' health and safety.

There is a level used to indicate the severity of exposure which is normal [100 - 75] %, probable over exposure [75-50%], serious over exposure [50-25] %, and very serious over exposure [25-0] %. According to pre and post cholinesterase levels, 109 subjects were taken from 15 plantations and 70% indicate normal. Size of plantation was identified as one of main contribution factors concerning time and frequency of pesticide usage. Pesticide usage in larger plantations requires a bigger amount of pesticide and workers to cover the entire area that leads to normal potential exposure (74%). However, in small plantations, only 34% respondents have the normal range of cholinesterase level due to improper handling technique and hygiene among the farmers. Figures 1 and 2 illustrate the distribution of severity of cholinesterase inhibition percentage based on size of the plantation.

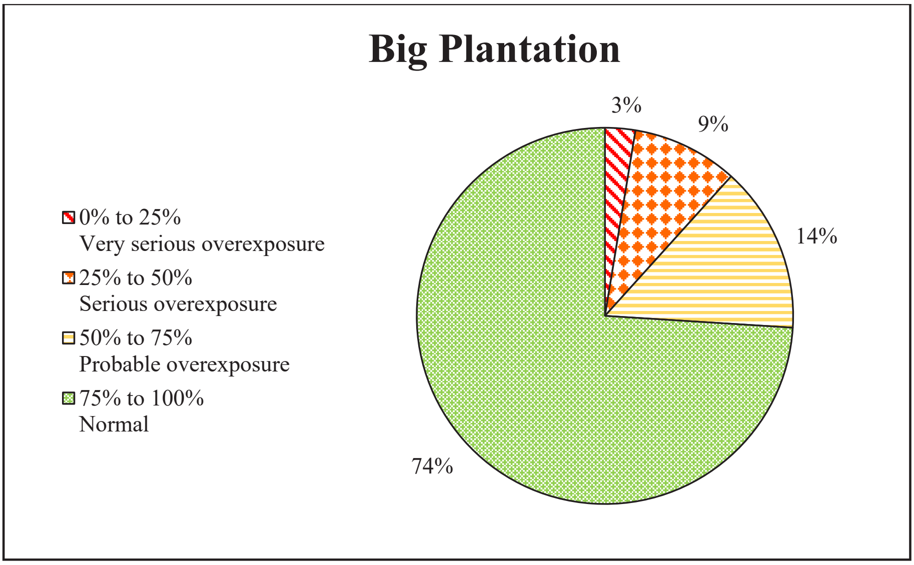

Figure 1: Percentage of Respondents with Varying Levels of Cholinesterase Inhibition in Big Plantations

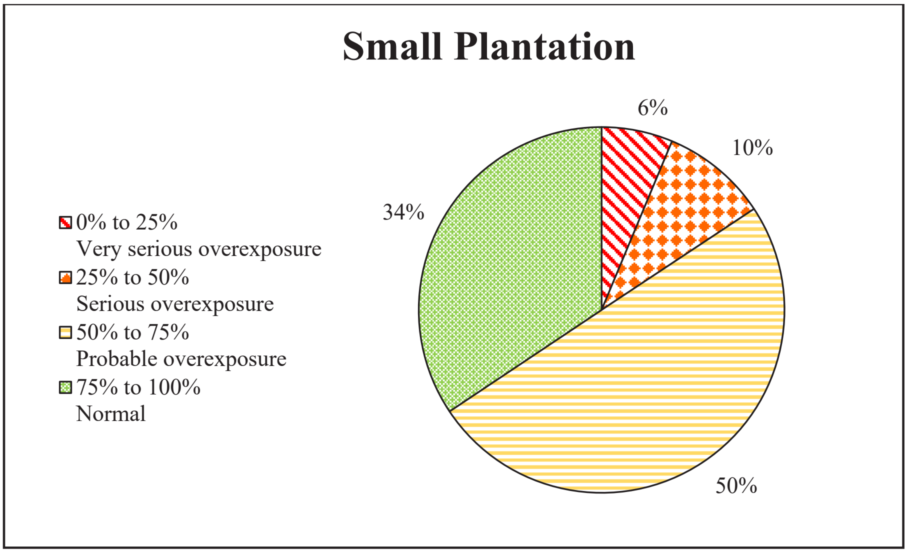

Figure 2: Percentage of Respondents with Varying Levels of Cholinesterase Inhibition in Small Plantations

This study summarizes that the size of the plantation may influence the sprayer's activity indirectly which leads to an increase of exposure to pesticides (Ramdan et al., 2020). The operations involved in larger plantations contribute to the large-scale usage of pesticides and workers. Thus, this activity highlights the potential for dermal exposure. Therefore, workers' health monitoring is important to identify the pesticide level among workers. Meanwhile, awareness among small-scale plantations should rise as the study indicates mild exposure among them caused by the carelessness of workers while handling the pesticides and the danger of pesticides. The risk of lack of awareness among workers causes most of them to disregard the main application of PPE.

Figure 3 illustrates the exposure level to pesticides that are classified based on states. Sabah and Kedah did not record very serious overexposure or serious overexposure. Meanwhile, Pahang showed 9 respondents recorded as very serious overexposure and serious overexposure while other states only had one or two subjects in the same category.

Probable overexposure was observed in all states and Pahang and Sabah have most number of respondent. In summary, Pahang led this category followed by Sabah and other states.

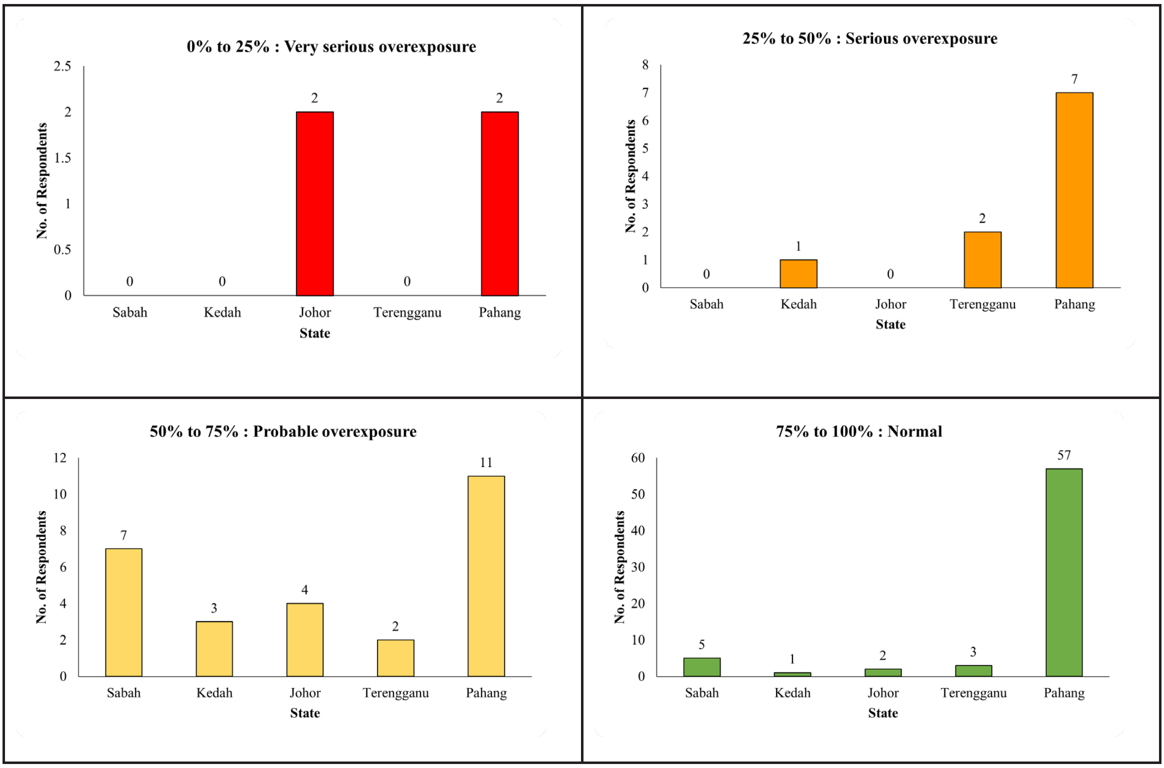

Figure 3: Number of Respondents with Severity of Exposure by State

The level of cholinesterase among 74% of workers in Pahang is normal, implying that their work practices and conduct were possibly right. This results from adequate training regarding occupational exposure that increases the workers' understanding and encourages them to be cautious when handling pesticides.

This study also reveals that certain workers, despite wearing gloves, have both mild and severe cholinesterase inhibition. This situation may have arisen as a result of neglecting to wear fresh gloves (Sookhtanlou & Allahyari, 2021).This observation supported a significant association ($p>0.05$) from correlation analysis between cholinesterase levels with work practices (Fajriani et al., 2019). Moreover, the correlation between cholinesterase level and touching contaminated surfaces was also moderately positively correlated $r= 0.34$, $p = 0.031$. Other factors like wearing PPE while handling pesticides and job tasks were found negatively correlated with $r = -0.42$, $p<0.01$. These findings indicate that work practices, contact with contaminated surfaces, and the use of personal protective equipment (PPE) are crucial determinants of the extent of pesticide exposure among workers. Thus, by enhancing these factors, the likelihood of cholinesterase depression and its related health risks might be substantially reduced.

5.0 CONCLUSION

Pesticide exposure levels among oil palm plantation workers revealed a diverse range, from severe overexposure to minimal or no exposure, as measured by cholinesterase levels. The identified risk factors, including poor work practices, and inadequate use of personal protective equipment, explained the need for targeted interventions. This study revealed that the group of small plantation workers observed higher impact, with a combined 16% of cases of serious overexposure and very serious overexposure. In contrast, the group of big plantation workers only had a total of 9% of such cases.

This study highlights the wider importance of dealing with the possible adverse health impacts of pesticide exposure, promoting the adoption of effective work practices and strict adherence to established standard operating procedures. Cholinesterase depression is highlighted as a vital objective measure for assessing pesticide exposure levels among agricultural workers, enabling the development of interventions to mitigate risks and protect worker health. Therefore, it is suggested that improvements to work practices, consistent utilization of personal protective equipment, and comprehensive training programs, with a particular emphasis on language barriers should be considered by the plantation management. Additionally, exploring alternatives to exclusive reliance on personal protective equipment, such as the use of less hazardous pesticides, is recommended to further reduce exposure risks. More research is needed to improve our understanding of potential pesticide exposure in employees. Overall, these findings provide valuable insights for policymakers, employers, and stakeholders to prioritize worker safety and minimize the adverse effects of pesticide exposure in the oil palm plantation sector.

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