

Association between Pesticide Exposure and Blood Cholinesterase Activities on Vegetable Farmers at Gintungan Village, Bandungan District, Semarang Regency

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Abstract:

Background: According to WHO, there are 1 to 5 million cases of pesticide poisoning worldwide. World Bank estimates 355,000 deaths each year due to accidental poisoning of pesticide exposure. Gintungan is one of the biggest vegetable producer area at Bandungan District, Semarang Regency and the farmers exposed to pesticides as a result of mixing and spraying pesticides. The results of measuring blood cholinesterase activities during the preliminary study showed that three respondents had abnormal blood cholinesterase activities.

Materials and Methods: This research was conducted on vegetable farmers using quantitative research methods of analytic observational research methods with cross-sectional approach. Data collection was carried out by interviewing farmers and the blood enzyme cholinesterase activities were tested by technician from Health Laboratory of Semarang using cholinesterase test with spectrophotometer. The chi-square test was used to analyze the association between pesticide exposure and blood cholinesterase activities. Samples were taken with a purposive sampling technique and 50 female vegetable farmers were enrolled in this research.

Results: The results of the univariate analysis found that 11 respondents (22%) showed abnormal levels of cholinesterase, 32 respondents (64%) had malnutrition status, 27 respondents (54%) age less than 39 years old, 15 respondents (30%) had more than 3 hours duration of mixing and spraying, 24 respondents (48%) spraying pesticides during the rainy season for more than 1 time per week, 8 respondents (16%) spraying pesticides during the dry season more than 1 time per week during dry seasons, and 48 respondents (96%) use a mixture of more than 2 pesticides in each spraying. The results of the bivariate test analysis found that age (p -value=0.007, RP = 5.283, 95% CI 1.267-22.023) and duration of spraying (p -value=0.01, RP = 4.08, 95% CI = 1.402-11.896) had association with blood cholinesterase activities. There are no association between the frequency of spraying pesticides during rainy season (p = 0.881 RP = 1.300, 95% CI 0.455-3.712), the frequency of spraying pesticides during dry season (p = 1.000 RP = 1.167, 95% CI 0.308-4.423), and the number of pesticide mixtures (0.395 RP = 0.417, 95% CI 0.094-1.852) with blood cholinesterase enzyme activities.

Conclusion: There are significant association between age (p -value= 0.007, RP = 5.283, 95% CI 1.267-22.023), duration of pesticide spraying (p -value=0.01, RP = 4.08, 95% CI = 1.402-11.896) and blood cholinesterase enzyme activities on vegetable farmers at Gintungan Village, Bandungan District, Semarang Regency.

Key Word: pesticide exposure; blood cholinesterase activities; female vegetable farmer; Gintungan Village

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I. Introduction

Pesticides in the agricultural sector are useful for controlling insects, fungi and weeds in crops.¹ Besides, pesticides are also called crop protector products which lead to increase agricultural production and reduce costs so that they are more economical and efficient.² According to WHO, there are 1 to 5 million cases of pesticide poisoning. The cases estimated at 220,000 deaths with 200,000 cases international.¹ Meanwhile, according to World Bank estimates, there are 355,000 deaths each year due to accidental poisoning due to pesticide exposure.^{3,4}

Research studies also carried out in developed countries where the results showed that the annual incidence rate of acute pesticide poisoning was 18.2 per 100,000 full-time farmers.^{5,6} In contrast, in developing countries including Indonesia, the reported incidence of pesticide poisoning was 80% or a total of casualties 12,000 per year.^{7,8}

The cholinesterase enzyme serves as a biomarker used to detect pesticide poisoning in farmers.⁹ The lower blood cholinesterase activities, the more pesticide poisoning is detected in farmers. Cholinesterase enzyme levels are normal in female aged ≤ 39 years. namely 4250-11,250 U/L, while for female aged > 39 years it is 5320-12,920 U/L.

Pesticide poisoning in farmers resulted in decreased blood cholinesterase activities. A decrease in cholinesterase can occur because the nerve impulse channels are blocked due to pesticides. Inhibition of nerve channels is carried out by binding to the cholinesterase enzyme, so that acetylcholine hydrolysis does not occur.¹⁰ Blockage of the nerve passages can occur within hours to weeks, depending on the type of anti-cholinesterase. The resistance carried out by the carbamate derivative only works for a few hours and has a reversible nature (back and forth). Meanwhile, barriers that have irreversible properties can be caused by phosphoric acid ester derivatives, which can damage the cholinesterase enzyme and new repairs arise after the body synthesizes the cholinesterase enzyme again.¹⁰

Spraying farmers are among the populations at risk of pesticide poisoning because of their involvement in agricultural activities such as spraying, mixing several types of pesticides, washing equipment, and harvesting agricultural products. Besides, the use of pesticides that are not proportional and not according to standards, especially if there are a pest attack and rainfalls, increases the risk of farmers exposed to pesticides. In this condition, farmers will spray quickly and increase the frequency of spraying. Use of pesticides without regulations is evidence of farmers' indifference to the dangers posed by pesticide exposure.¹¹

Pesticides enter the farmer's body through three events, namely inhalation (breathing), ingestion (digestion), and unprotected skin surfaces. The effects of pesticide exposure on health are that pesticides are mutagenic and neurotoxic, carcinogenic, endocrine disruptor and system disruptor.^{12,13} Other disadvantages caused by the use of pesticides are headache, difficulty breathing, neurological effects, psychological effects, irritation of the skin and mucous membranes. Manifestations of this impact depend on the type of pesticide used and the duration of exposure to the sprayer.¹⁴

Gintungan is one of the largest vegetable producing areas in Bandungan District, Semarang Regency and in eradicating pests on vegetables using pesticides. As a result, if the pesticide used is not in accordance with the procedure for use and most farmers are not aware about the dangers of pesticide exposure and it can cause poisoning to farmers, farm families and surrounding communities.

A preliminary study was conducted with female farmer respondents who work in the agricultural area of Bandungan Village, Bandungan District, Semarang Regency. A preliminary study has been conducted with female farmer respondents who work in the agricultural area of Bandungan Village, Bandungan District, Semarang Regency. Female farmers were chosen as research subjects because female were more susceptible to pesticide poisoning. Female have special conditions such as pregnancy, menstruation, and breastfeeding. During pregnancy, female have an average level of the enzyme cholinesterase, which tends to fall. If this particular condition in female is not considered, it will worsen the cholinesterase enzyme levels.

The use of pesticides in the application carried out by spraying 2-4 times/week. Spraying will be carried out by farmers when pests and diseases attack the plant. The mixing of pesticides by farmers is more than four types of pesticides in one crop spray. The pesticide mixture consists of insecticides, fungicides, adhesives and growth regulators. The highest percentage of pesticide use is from dinitroaniline (70%), carbamate (60%) and organophosphate (35%).

The results of measuring the cholinesterase enzyme levels during the preliminary study showed that three respondents had abnormal cholinesterase enzyme levels. Health symptoms that are often felt by vegetable spray farmers in Gintungan are dizziness, nausea, weakness and fatigue. The incidence of abnormal cholinesterase enzyme levels in female spraying farmers is related to pesticide exposure in the agricultural sector which results in a decrease in cholinesterase enzyme levels. The sustainable use of pesticides will cause pesticides to enter the body of farmers and lead to accumulation of pesticide residues in the blood.

Based on the description, this research aims to analyze the association between pesticide exposure to vegetable spray farmers and blood cholinesterase activities in Gintungan, Bandungan District, Semarang Regency.

II. Material And Methods

This research used quantitative research using analytical observational research methods with a cross-sectional design. The study population was 97 female farmers who mixing and spraying vegetables Gintungan, Bandungan District, Semarang Regency. Data collection was carried out by interviewing farmers observation on the field and the blood enzyme cholinesterase activities were tested by tehcnical from Health Laboratory Semarang.

Study Design: Observational methods with a cross-sectional design

Study Location: Gintungan, Bandung District, Semarang Regency.

Study Duration: October 2018 to April 2019

Sample size: 50 respondents.

Sample size calculation: The number of farmers enrolled in this research 50 and were taken using the Slovin formula for number of samples with the inclusion criteria Female farmers, age between 20-65 years, willing to participate as a research sample had been living at Gintungan, Bandungan District.

Subjects & selection method: Subject in this research was vegetable farmer had been living at Gintungan, Bandung District. Sampling was taking with a nonprobability sampling approach with a collection technique that is purposive sampling

Procedure methodology

Cholinesterase enzyme measurements were carried out at the Central Java Health Laboratory Center using cholinesterase test with spectrophotometer.

Statistical analysis

The independent variables in this study include age, duration of spraying, frequency of spraying pesticides during rainy season, frequency of spraying pesticides during during dry season, and the number of pesticides mixture. The independent and dependent variables were obtained from primary data from interviews and the measurement of blood enzyme cholinesterase activities.

Secondary data collection obtained from the Central Bureau of Statistics of Semarang Regency and monograph of Bandungan Village Primary. Data obtained by interview and measurement of blood cholinesterase activities. Primary and secondary data collected then carried out editing, coding, data entry, data cleaning, and data tabulation.

Univariate analysis and bivariate analysis are the analysis used in this study. Bivariate analysis to see the association between two variables (independent variables and dependent variables) which were analyzed using chi-square with a value of $\alpha = 0.05$.¹⁴ The univariate and bivariate analysis used SPSS, and the results obtained from the bivariate analysis were in the form of the p-value, then the p-value was compared with $\alpha = 0.05$. If the p-value is less than $\alpha = 0.05$, then there is a association between the independent and dependent variables. The interpretation of the analysis is that if the p-value obtained, it concluded that there is a significant association between the variables.

III. Result

Table no 1 shows distribution of the characteristics of the research respondents in Gintungan, Bandungan District, Semarang Regency has age characteristics dominated by respondents aged ≤ 39 years, with 27 respondents (54%). The majority of respondents had the latest level of education, namely graduated from elementary school with 28 respondents (56%). A total of 32 respondents (64%) had poor nutritional status with a body mass index of more than 25.

Table no. 1: Distribution of Respondent Characteristics in Gintungan, Bandungan District, Semarang Regency

Individual Characteristics	Total	%
Age		
> 39 years old	23	46
≤ 39 years old	27	54
Education Level		
Not completed in primary school	8	16
Graduated from elementary school	28	56
Graduated from JHS	9	18
Graduated from SHS	5	10
Status Nutrition		
Bad	32	64
Good	18	36

Table no 2 shows distribution of cholinesterase enzyme levels in blood in vegetable spraying farmers in Gintungan, Bandungan District, Semarang Regency who are abnormal in 11 respondent (22%).

Table no 2: Distribution of Blood Cholinesterase Activities in Vegetable Spraying Farmers in Gintungan, Bandungan District, Semarang Regency

Blood Cholinesterase Activities	Total	%
Normal	39	78
Abnormal	11	22

Table no 3 shows distribution of pesticide exposure to respondents at Gintungan, Bandungan District, Semarang regency. The age of respondents in Gintungan, Bandungan District, Semarang Regency has an average age of 38.36 with a standard deviation of 11.581 with a youngest age was 21 years and the oldest age was 63 years. The increase in age caused the average of blood cholinesterase activities to be lower and caused pesticide poisoning.¹⁴ The duration of spraying carried out by respondents was at least 1 hour and a maximum of 5 hours with an average the duration of spraying is 2.83 hours and a standard deviation as much as 0.976. The longer respondents spray pesticides, the greater the risk of exposure to pesticides and can cause pesticide poisoning.

The frequency of spraying pesticides during rainy season was carried out by respondents at least 1 time/week and at most done as much as 4 times/week with an average spraying frequency is 1.68 times/week and a standard deviation as much as 0.844. Meanwhile, the frequency spraying pesticides during dry season at least 1 time / week and at most done as much as 3 times/week with an average spraying frequency is 1.18 times/week and a standard deviation as much as 0.438. Pesticide spraying frequency proportional to the risk of pesticide poisoning. The more often farmers spray pesticides, the higher the risk of pesticide poisoning. The more use of the number of pesticides, the stronger the toxic power or its concentration, resulting in greater side effects. The number of pesticide mixture used by respondents ranged from 1 type (single) and at most are 6 types with an average of 3.7 types of pesticides used and had a standard deviation as much as 1.233. Blood cholinesterase activities of the research respondents had an average cholinesterase enzyme of 6464.6 U/L, a standard deviation of 1428.272, a minimum of 4041 U/L of cholinesterase enzyme, and a maximum of 9384 U/L.

Table no 3: Distribution of Pesticide Exposure to Respondents at Gintungan, Bandungan District, Semarang Regency

No.	Variable	Min	Max	Mean	Median	SD
1.	Age	21	63	38.36	38,50	11.581
2.	The Duration of Spraying (hours)	1	5	2.84	3	0.976
3.	The Frequency of Spraying Pesticides during Rainy Season (times/week)	1	4	1.68	1	0.844
4.	The Frequency of Spraying Pesticides during Dry Season (times/week)	1	3	1.18	1	0.438
5.	The Number of Pesticide Mixture	1	6	3.7	4	1.233
6.	Blood Cholinesterase activities	4041	9384	6464.6	6542	1428.272

Table no 4 shows association of risk factors of pesticide exposure with blood cholinesterase activities. P-value of age is 0.007; spraying time is 0.01, the frequency of spraying pesticides during rainy season is 0.881; the frequency of spraying during the dry season 1.000; and number of mixture types of pesticides is 0.395.

Table no 4: Association of Risk Factors of Pesticide Exposure with Blood Cholinesterase Activities

Variabel	Blood Cholinesterase Activities						p-value	RP (95% CI)
	Abnormal		Normal		Total			
	n	%	n	%	n	%		
Age								
> 39 years old	9	39,1	14	60,9	23	100	0.007	5.283
≤39 years old	2	7,4	25	92,6	27	100		(1.267-22.023)
The Duration of Spraying								
> 3 hours	7	46,7	8	53,3	15	100	0.01	4.083
≤ 3 hours	4	11,4	31	88,6	35	100		(1.402-11.896)
The Frequency of Spraying Pesticides during Rainy Season								
> 1 time / week	6	25	18	75	24	100	0.881	1.300
≤ 1 time/week	5	19,2	21	80,8	26	100		(0.455-3.712)
The Frequency of Spraying Pesticides during Dry Season								
> 1 time / week	2	25	6	75	8	100	1.000	1.167
≤ 1 time/week	9	21,4	33	78,6	42	100		(0.308-4.423)
The Number of Pesticide Mixture								
> 1 type	10	20,8	38	79,2	48	100	0.395	0.417
≤ 1 type	1	50	1	50	2	100		(0.094-1.852)

IV. Discussion

This research showed that out of a total of 23 respondents aged >39 years, as many as 9 people (39.1%) had abnormal blood cholinesterase activities. Meanwhile, from 27 respondents who were ≤ 39 years old, as many as 2 people (7.4%) had abnormal blood cholinesterase activities. Statistical test results proved that there is a significant association between age and blood cholinesterase activities. This research showed that out of a total of 23 respondents aged >39 years, as many as 9 people (39.1%) had abnormal blood cholinesterase activities of vegetable sprayers at Gintungan, Bandungan District, Semarang Regency (p-value = 0.007; RP = 5.283; 95% CI = 1.267-22.023) which means that vegetable sprayers aged >39 years old had a 5 times greater risk compared to vegetable sprayers aged ≤39 years old.

Increasing age makes a person more sensitive and decreases ability of the body to process chemicals in pesticides efficiently. Therefore, the older the farmers are, they should consider taking more preventive measures to reduce cholinesterase levels by minimizing pesticide exposure.

Age-related differences in sensitivity to pesticides can be caused by several factors. Toxicokinetic differences among age groups contribute to differential sensitivity, with biotransformation differences often as a major factor. Absorption rates against pesticides can contribute to differential sensitivity among age groups in some cases. Differences in toxicodynamics can also contribute to age-related sensitivity. The ability to restore function after exposure to toxins may be higher in some age groups.¹⁵

The duration of spraying will have an effect on the incidence of pesticide poisoning and this is an external factor. The results of bivariate analysis showed that out of 15 respondents with > 3 hours of spraying, as many as 7 people (46.7%) had abnormal blood cholinesterase activities. Meanwhile, out of 35 respondents with as much as ≤ 3 hours of spraying, as many as 4 people (11.4%) had abnormal blood cholinesterase activities. Statistical test results proved that there was a significant association between the duration of spraying with blood cholinesterase activities of vegetable spraying farmers at Gintungan, Bandungan District, Semarang Regency (p-value = 0.01; RP = 4.083; 95% CI = 1.402-11.896). This indicates that vegetable spraying farmers with a length of >3 hours spraying have a 4 times greater risk than vegetable spraying farmers with a ≤ 3 hours of spraying. On average, farmers in Gintungan sprayed in onetime work for $2.84 \approx 3$ hours. Generally, farmers do pesticide spraying in the morning and evening. Pesticide spraying with a duration of spraying more than 3 hours without rest will result in the occurrence of chronic poisoning.¹⁶ In spraying pesticides, the duration should not exceed 3 hours because it will increase the risk of poisoning. If farmers still have to get the job done, it should take a while to give the body a chance to be free from pesticide exposure.¹⁷

The frequency of pesticide spraying is not related to pesticide poisoning characterized by a decrease in cholinesterase activity in the blood.¹³ The results of bivariate analysis showed that out of a total of 24 respondents with the frequency of spraying pesticides during rainy season > 1 time / week, as many as 6 people (25%) which has abnormal blood cholinesterase activities. While from a total of 26 respondents with the frequency of spraying pesticides during rainy season ≤ 1 time / week, as many as 5 people (19.2%) which has abnormal blood cholinesterase activities. Statistical test results proved that there was no significant association between the frequency of spraying pesticides during rainy season and blood cholinesterase activities of vegetable sprayers in Gintungan, Bandungan District, Semarang Regency (p-value = 0.881; RP = 1.300; 95% CI = (0.455-3.712)).

In this research, the frequency of spraying pesticides during rainy season was not directly related to blood cholinesterase activities. There is no association that can be affected by the amount of pesticide mixture, length of exposure etc. The occurrence of rain after spraying pesticides can dissolve or remove pesticides from the surface of plants. Spraying pesticides during heavy rainy seasons is also less effective because most of the pesticides used will be flushed by the rain.¹⁷

While bivariate analysis on the frequency of spraying pesticides during dry season showed that out of a total of 8 respondents with the frequency of spraying pesticides during dry season > 1 time/week, as many as 2 people (25%) which has abnormal blood cholinesterase activities. While from 42 respondents with the frequency of spraying pesticides during dry season ≤ 1 time/week, as many as 9 people (21.4%) which has abnormal blood cholinesterase activities. Statistical test results proved that there was no significant association between the frequency of spraying pesticides during the dry season and blood cholinesterase activities of vegetable sprayers in Gintungan, Bandungan District, Semarang Regency (p-value = 1.000; RP = 1.167; 95% CI = (0.308-4.423)).

There is no association between the frequency of pesticide spraying during the dry season and blood cholinesterase activities because the intensity of pesticide spraying in the dry season tends to be less than the frequency of pesticide spraying during the rainy season. The cause of the difference in spraying intensity is because during the rainy season pesticides can dissolve due to rain so it is necessary to do repetition to maximize the effectiveness of pesticides in eradicating pests or plant pests.¹⁸ This research is in line with Samosir (2017) analysis, which states that there is no association between spraying frequency and blood cholinesterase activities. The acute effect of acetylcholinesterase enzyme activity is only temporary and generally lasts 1 to 2 weeks.²

In this research, the number of pesticide mixtures had no association with blood cholinesterase activities. The results of bivariate analysis showed that out of a total of 48 respondents who used a mixed types of pesticides, as many as 10 people (20.8%) had abnormal blood cholinesterase activities. Meanwhile, from 2 respondents who used a mixed types of pesticides, as many as 1 person (50%) had abnormal blood cholinesterase activities. Statistical test results proved that there was no significant association between number of pesticide mixtures with blood cholinesterase activities of vegetable spraying farmer in Gintungan, Bandungan District, Semarang Regency (p-value = 0.395; RP = 0.417; 95% CI = (0.094-1.852)).

In this study, the amount of a mixture of pesticides had no relationship with blood cholinesterase activities. The bivariate analysis results showed that from a total of 48 respondents who used a mixture of pesticides, 10 people (20.8%) had abnormal blood cholinesterase activities. Meanwhile, of the 2 respondents who used ≤ 1 type of pesticide, 1 person (50%) had abnormal blood cholinesterase activities. There is no association between the amount of pesticide mixture and blood cholinesterase activities. A suitable spray method can be caused by paying attention to the wind's direction, spraying time, ambient temperature, and length of work. Besides, the use of pesticides with properties that are not too toxic, the dosage is not extensive, and the land area is not large are some other factors that cause no association between the types of pesticides used and the decreased blood cholinesterase activities.

V. Conclusion

Based on the results of this study, it can conclude that as many as 11 respondents (22%) had abnormal blood cholinesterase activities with an average of 6464.6 U/L. There is a significant association between age (p -value = 0.007, $RP = 5.283$, 95% CI 1.267-22.023) and duration of spraying (0.395 $RP = 0.417$, 95% CI 0.094-1.852) with blood cholinesterase activities of vegetable sprayers in Gintungan, Bandungan District, Semarang Regency. Vegetable sprayers aged > 39 years have a risk level 5 times greater than vegetable sprayers aged ≤ 39 years. While in farmers who serve as sprayers with a duration of spraying > 3 hours, has a risk level 4 times greater than vegetable sprayers with a duration of spraying ≤ 3 hours.

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