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ORIGINAL RESEARCH ARTICLE

Utilization of personal protective equipment and the hygiene sanitation practices of farmers in the application of pesticides

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ABSTRACT

BACKGROUND AND OBJECTIVES: Pesticides are toxic and dangerous materials requiring good handling. Pesticide exposure highly affects farmers' health, especially spray pesticides, which arise from pesticide residues in food, air, and the environment. This research aims to determine the relationship between behavioral factors in using Personal Protective Equipment and individual hygiene and sanitation of farmers who experience health problems. This study also looks at the predictive value of farmers' behavioral factors regarding health problems.
METHODS: The design of this study is cross-sectional with quantitative research type. This study gathered 91 respondents in Jonggol Village, which has the largest agricultural land in Bogor Regency and with farmers who actively use pesticides. Accordingly, this location has a population at risk of pesticide exposure. This study used questionnaires to obtain information about farmer behavior and health problems. It also used the statistical package for the social sciences application to analyze data based on the chi-square test and multiple logistic regression.
FINDINGS: The bivariate analysis results show a significant relationship between the habit of using personal protective equipment (masks) and farmers' health problems, with a test value of 0.019 and an odds ratio of 4.24. The habit of not using hand protection (gloves) is also significantly related to not showering after farming, with a test value of 0.045 and an odds ratio of 3.61. Meanwhile, the variable habit of using hand protection (gloves) has the highest influence, with a test value of 0.008. Farmers who do not use hand protection are 17.5 times more likely to experience health problems than farmers who use hand protection. Meanwhile, the Logistic Model shows that all variables lack a significant relationship.
CONCLUSION: Based on the overall analysis of the behavior of using personal protective equipment and personal hygiene of farmers, this study suggests increasing synergy between agricultural and health instructors in building awareness of using protective equipment and the correct and appropriate use of pesticides among farmers. In a cross-program and cross-sector manner, agricultural extension workers can explain how to wear protective equipment and use pesticides correctly, while health educators can promote pesticide exposure pathways and preventive measures for pesticide-related diseases. Exploring other factors influencing farmers' willingness to use protective equipment and maintain personal hygiene is also essential, including barriers preventing farmers from behaving well. Good pesticide use behavior will maintain the health of farmers and build the health of farmer families and the surrounding community.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
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INTRODUCTION

Pesticides are used to prevent losses due to pest attacks on plants, improve the quality of agricultural products, and protect fruits to attract consumers (Bernardes *et al.,* 2015; Ehzari *et al.,* 2022; Parsafar *et al.,* 2023). The use of pesticides is seen as a cost-effective, labor-saving, and efficient method of pest control and agricultural production. Pesticide consumption is estimated at more than five billion kg annually (FAO/WHO, 2014). However, serious concerns arise regarding the health impacts on farmers due to pesticide exposure, especially spray pesticides arising from residues in food and water, both in the long and short term through the food chain (Zhang *et al*., 2017). Non-target creatures, food chains, and biodiversity can be affected, posing profound dangers to human health and the environment (Samimi *et al.,* 2023). The FAO/WHO (2014) report states that pesticides poison 43 percent (%) of the Zimbabwean population, 25% of the Mexican population, and 23% of Indian farmers and agricultural workers. In several European countries, pesticides are also known to have a negative impact on the health of farmers and vulnerable groups such as pregnant women (Liu *et al*., 2023). Several countries in Asia have found health problems among farmers who actively use pesticides (Xu *et al*., 2023). Pesticide exposure can occur in every individual. Farmers and agricultural workers are the groups most at risk due to pesticide exposure and additional workplace exposure risks (Balasha *et al*., 2023). ILO (2013) reports that yearly, many agricultural workers and farmers are injured or sick. Approximately 25 million farmers and agricultural workers experienced moderate pesticide poisoning, and three million farmers and agricultural workers experienced severe pesticide poisoning, resulting in approximately 180,000 deaths among agricultural workers in rural areas in developing countries. This condition is caused by wrong perceptions, lack of knowledge, education, law, and unintentional implementation errors (Ali *et al*., 2020). Pesticides, heavy metals (Samimi, 2024) and other toxic compound can pollute agricultural environments such as water, soil, and air, impacting local communities through inhalation, skin, and mouth (Liu *et al*., 2023; Samimi and Nouri, 2023). Previous research found that pesticide poisoning in agricultural workers can cause acute illness (Al-Dawood *et al*., 2023) such as severe headaches, dizziness, skin and eye irritation, coughing, and rhinitis (Koussé *et al*., 2023). Pesticide exposure can also cause chronic diseases such as cancer (Ali *et al*., 2020), leukemia, and brain tumors (Koussé *et al*., 2023). The farmers' use of pesticides requires attention in the area of risk management. Farmers must use personal protective equipment (PPE) according to the Pesticides Commission's standard procedures, including masks, gloves, foot protectors, and protective clothing. Farmers must wear masks to minimize exposure to pesticides that enter the body through the air. The types of masks that can be used are ordinary, surgical, and Non-oil 95 (N95). N95 masks filter smaller particles more than surgical masks. However, the mask must be changed every 8 h because if worn for too long, the filtered particles will accumulate on the mask. Consequently, the former will prevent the latter from functioning optimally. Farmers should also maintain personal hygiene by cleaning themselves immediately after spraying pesticides to reduce the risk of exposure to pesticide particles. Good personal hygiene means washing your hands and showering immediately after mixing and spraying pesticides. Indonesia now has coercive regulations to encourage farmer compliance in agricultural activities through the Law of the Republic of Indonesia no. 22 of 2019 concerning sustainable agricultural cultivation systems. This regulation prohibits agricultural cultivation methods threatening human health, safety, and the environment. Indonesian farmers face risks from using toxic chemical pesticides with application techniques that do not comply with regulations, inadequate spraying equipment that lacks appropriate personal safety equipment, and the frequent reuse of old pesticide containers (Garcia *et al*., 2012). Based on a review of previous reports, analytical research is extremely important to determine the determinant and dominant factors that influence farmers' health based on PPE. Meanwhile, previous research generally focuses on the level of pesticide residue contamination (Khatun *et al.,* 2023), perceived health impacts (Ssemugabo *et al*., 2023), type of pesticide residue (Atnafie *et al*., 2021), and self-descriptive use of protective equipment (Kangkhetkron and Juntarawijit, 2021). Thus, a research gap exists in analyzing the causal relationship between exposure to specifications and disease incidence in farmers. This study aims to determine the relationship between behavioral factors in using PPE and the hygiene and sanitation of individual farmers who experience health problems. This study also aims to determine the most dominant determinants influencing potential health problems in farmers. Bogor City is one of the agricultural areas in Indonesia. Meanwhile, Jonggol Village is one of the sub-districts under the administrative area of Bogor City. Based on preliminary research conducted in Jonggol Village, most farmers experienced health problems and low use of PPE and sanitation. Thus, this study was conducted in Jonggol Village, Indonesia, in 2023.

MATERIALS AND METHODS

The population of this study covers all areas with agricultural areas in Jonggol District, Bogor Regency. Jonggol District consists of 14 villages, namely Sukajaya, Sukagalih, Sukanegara, Weninggalih, Cibodas, Sukamanah, Singasari, Sukamaju, Singajaya, Jonggol, Sukasirna, Bendungan, Balekambang, and Sirnagalih Villages (Fig. 1). This study uses a cross-sectional and quantitative research design. The sample area is the village with the most extensive agricultural land in Jonggol District, namely Jonggol Village. This village has agricultural land covering an area of 833 hectare (ha). Farmers in Jonggol Village are users of triazole pesticides, thereby rendering them vulnerable to pesticide exposure.

Research site

This study starts from the preparation of the proposal and ends with the results report. The study location is centered on the location used by farmers to carry out farming activities and spray pesticides. The sample region or sample area is the village with the largest agricultural land area in Jonggol District. The village is Jonggol Village, with an agricultural land area of 833 ha. The largest village, namely Jonggol Village, was chosen after discovering that farmers use triazole pesticides and based on the focus of the study. This study uses a non-probability sampling technique, which means that not all elements in the population have the same chances of becoming the desired sample. The sample in this study only

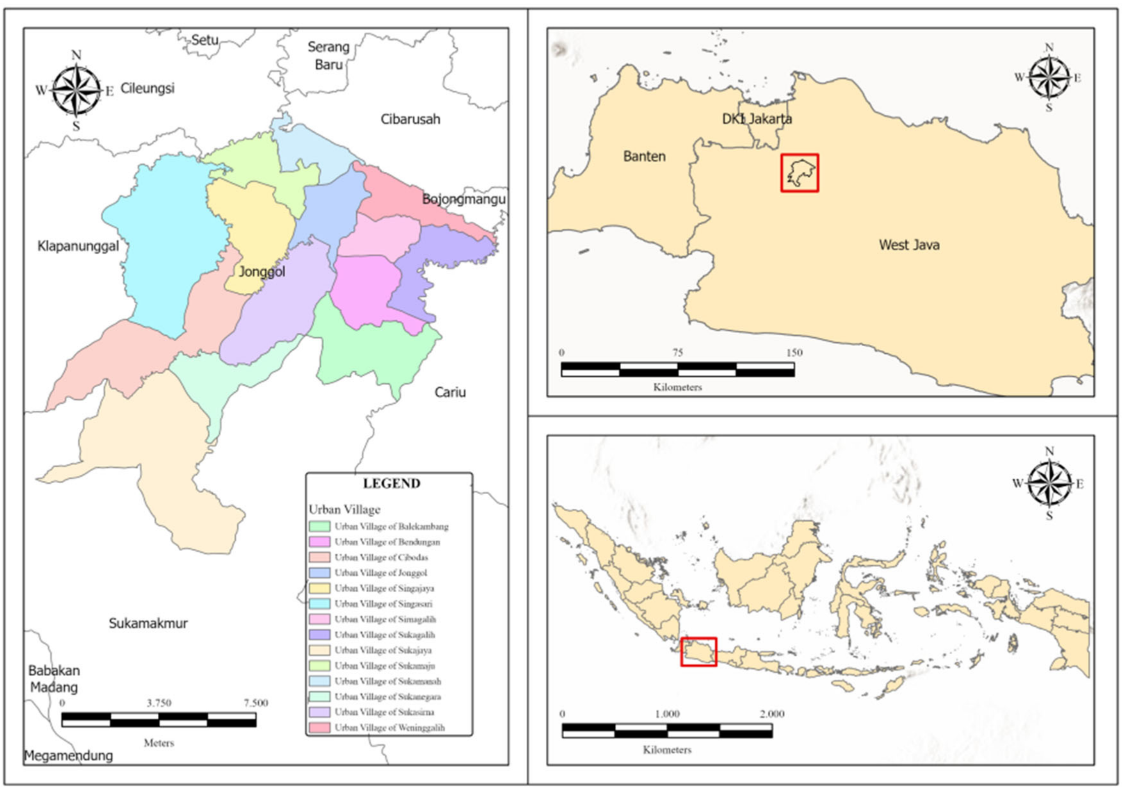

Fig. 1: Geographic location of the study area in the agricultural residential area of Jonggol Village of Jonggol Sub-District in Indonesia

comprised farmers because they are the group most at risk of exposure to pesticide residues. Farmers spend quite a long time in agricultural areas in their daily lives when spraying or applying pesticides to their crops. Thus, they are likely exposed to pesticide residues. Researchers used the Slovin formula to determine the sample size because the number must be representative in taking samples. Thus, the study results can be generalized. The Slovin formula is used for determining a sample of farmers as in Eq. 1 (Jamil *et al*., 2023).

$$n = \frac{N}{1 + Ne^2}, \qquad (1)$$

where
n = Total of samples taken for research
N = Total farming population by village
e = Degree of tolerance for inaccuracy in retrieval sample

The study uses a tolerance level of 10%. Thus, the sampling calculation is performed using Eq. 2 (Jamil *et al*., 2023).

$$n = \frac{n}{1 + 975(0.01)^2} = 90.69 = 91 \text{ farmers}. \qquad (2)$$

Survey

This study first conducted preliminary research to collect initial information regarding the research location. Preliminary research involved ten Jonggol Village farmers in the interview process. Interview results show that 8 out of 10 farmers have worked as farmers for more than ten years. The majority of farmers experience respiratory and digestive health problems. The PPE used is incomplete. At most, farmers use three types of PPE, namely masks, gloves, and protective clothing. Farmers generally shower after spraying pesticides. The results of this interview were then used as material for consideration in preparing the research instrument. This study uses a questionnaire instrument to survey farmers in selected research locations. The questionnaire consists of 1) respondent identity, such as gender, age, and education level; 2) history of working as a farmer; 3) use of personal protective equipment such as masks, gloves, and protective clothing; 4) sanitary hygiene, such as showering after using pesticides; and 5) farmer health problems such as complaints of illness in the last year, both respiratory and digestive health problems (Table 1).

Based on Slovin's calculations, the number of samples in the study was 91 lowland rice farmers. All samples are farmers from Jonggol Village, the group most at risk of exposure to pesticides because they consume raw water sources in agricultural areas and carry out pesticide spraying and mixing activities. This study uses a non-random sampling technique, namely quota sampling. This study only took a

Table 1: Study questionnaire

Questions	
Respondent identity	
Sex	Male or female
Age (year)	26–65; ≥66
Education level	Elementary school (Sekolah dasar/SD); Junior high school (Sekolah menengah pertama/SMP); Senior high school (Sekolah menengah pertama/SMA); Bachelor's Degree (Strata 1/S1)
History of working as a farmer	
How long have you worked as a farmer?	Over 10 years; between 5 and 10 years
Use of PPE	
Do you wear a mask when spraying pesticides?	Yes or no
Do you wear gloves when spraying pesticides?	Yes or no
Do you wear long clothes when spraying pesticides?	Yes or no
Sanitation hygiene	
Do you shower immediately after spraying pesticides?	Yes or no
Farmers' health problems	
Have you had any complaints of illness during the last year?	Yes or no
Do you have respiratory health problems?	Yes or no
Do you have digestive health problems?	Yes or no

sample of farmers because they are the "population at risk" for exposure to pesticides due to their pesticide spraying activities, mixing pesticides, and presence in locations where pesticide residues may remain around the farm. The inclusion criteria for the sample of farmers are willing to be a respondent, able to communicate well, farmers who have worked permanently for more than one year, farmers who spray pesticides, and farmers who mix pesticides. Meanwhile, the exclusion criteria for the sample of farmers are farmers who work as a side job, absent in the target location after three visits, and farmers who do not spray mix pesticides.

Analysis procedures

This study uses a questionnaire instrument that contains demographic characteristics, behavior toward using PPE, behavior toward maintaining personal hygiene and sanitation, and farmers' identified health problems, including digestive and respiratory disorders. The process of obtaining additional data not only happens through interview methods but also observation and documentation regarding farmer behavior in Jonggol Village. From March to April 2022, data were collected through direct field surveys using open and closed questionnaires. This study screened respondents by meeting the research inclusion criteria. The purpose of the study will be explained to selected potential respondents. If the prospective respondent agrees to participate in this study, such respondent will sign an informed consent. All samples in this study have signed informed consent.

Data collection

This study uses two types of data, namely primary and secondary. Primary data in this study are data from interviews with farmers. Primary data are a data source directly provided to data collectors. Secondary data in this study consist of data on the number of farmers and the area of rice farming areas in Jonggol Village obtained from the Central Statistics Agency of Jonggol District, the Bogor Regency Agriculture, Plantation and Forestry Service, the Bogor Regency Health Service, and the Food Crop Protection Center and Horticulture of West Java Province (BPS Kota Bogor, 2021). Two field researchers contacted potential respondents at the farmer group head center and surrounding areas to explain the research objectives and thereafter obtain approval. After obtaining their consent to participate in survey activities, 91 respondents received questionnaires which were distributed using the convenience sampling method. Data collection through surveys is then carried out on site. Table 2 presents the details of the data collection for this study.

Statistical analysis

Data analysis is carried out after passing the processing data stage into information. The information obtained is used for the decision-making process. The entire data processing and analysis process uses SPSS software. Data processing is achieved through the following four steps: editing, coding, data entry, and data cleaning. The collected data then go through a descriptive analysis or univariate analysis process to determine the type of data distribution. Meanwhile, to determine the distribution of data, this study uses a normality test to detect the distribution of data. Normally distributed data must meet the test value of more than 0.05 (p-value > 0.05). Next, bivariate analysis was carried out to determine the relationship

Table 2: Data collection

Content	Jenis data	Methods	Sources	Descriptions
Demographic characteristics of farmers in Jonggol Village	secondary	Document analysis	BPS Kota Bogor	Data on the number of farmers and the area of rice farming in Jonggol Village
Respondent identity	Primary	Questionnaire	Respondents	Gender/age/education level
History of working as a farmer	Primary	Questionnaire	Respondents	How long the respondent has been a farmer in years
Use of PPE	Primary	Questionnaire	Respondents	Wear masks, gloves, and protective clothing when spraying pesticides
Sanitation hygiene	Primary	Questionnaire	Respondents	Bathing after spraying pesticides
Farmers' health problems	Primary	Questionnaire	Respondents	Complaints of illness in the past year, history of respiratory and digestive problems

between the dependent and independent variables. The dependent variable is health problems, while the independent variable is farmers' behavior toward using PPE and sanitation. Logistic regression analysis is also relevant to analyze the direction and correlational relationships because this study focuses on theory development. Logistic regression analysis does not require a solid theoretical basis. Accordingly, such analyses may be suited for theory development. The study hypotheses are as follows:

Hypothesis 1: A relationship exists between the habit of not using mouth/face protection (masks) and the emergence of health problems.

Hypothesis 2: A relationship exists between the habit of not using hand protection (gloves) and the emergence of health problems.

Hypothesis 3: A relationship exists between the habit of not using protective clothing and the emergence of health problems.

Hypothesis 4: A relationship exists between the habit of not bathing after farming and the emergence of health problems.

RESULTS AND DISCUSSION

The latitude of Jonggol village is -6.479789, and the longitude is 107.045101. This village is located 100 m above sea level and has a tropical rainforest climate with rainfall of 30 m3. The boundaries of Jonggol are Sukamanah to the north, Sukasirna to the south, Sirnagalih to the east, and Sukamaju to the west. The land use is 833 ha for rice fields, 180 ha for fields/fields, and 2,360 ha for residential areas. Jonggol has a yard area of 580 ha, a plantation of 3,250 ha, and public facilities of 670 ha. Jonggol Village has a water and river irrigation system and healthy water (groundwater) close to agricultural activities. The majority of residents work as farmers in Jonggol Village. Agricultural activities in the Jonggol Village location still actively use pesticides. Farmers and residents living in the Jonggol Village location are at risk of contamination by pesticide exposure from drinking water sources around the agricultural area. Farmers in Jonggol Village have a community called, POKTAN "Farmers' Group." Among them are the Harapan Tani Farmers Group and the Guyub Tani Farmers Group. Most farmers in Jonggol Village work as rice farmers and carry out rice planting activities for 900 days. Agricultural activities start in April. The first week is the essential fertilization time. Fifteen days after the first fertilization activity, the second fertilization activity is carried out. After 35 days, it is continued with the third fertilization activity. Along with fertilization activities, farmers in Jonggol Village are also actively spraying pesticides to reduce the risk of damage to rice plants by leafhoppers by using fungicides and pesticides. Farmers in Jonggol Village most often use fungicides with the "E-Score" label or brand. The majority of farmers are also active in mixing pesticides. Farmers in Jonggol Village use phosphate, nitrite, nitrate, and MPK fertilizers. Some farmers who work in Jonggol Village also have other activities apart from farming, and some have businesses as fishing owners, trade, and businesses by owning stalls.

Farmers' demographic characteristics in Jonggol Village

Table 1 shows that 93.4% of respondents were male, 6.6% were female, 82.4% had an age range of < 26–65 years, and 17.6% had an age range of more than or equal to (≥) 66 years. Farmers who have their last level of education at SD account for 89%, 5.5% of workers in the tourism sector have their last level of education at SMP, 4.4% of farmers have their last level of education at SMA, as many as 1.1% of farmers have the last level of education at Bachelor's Degree. The dominant farmers have worked as farmers for over ten years, namely 95.6% (87 farmers), and 4.4% of farmers work long term for 5 to 10 years. The characteristics of the farmers in this study align with the study of Li *et al*. (2023), who found that most farmers were men and, on average, had worked as farmers for more than ten years (Zuo *et al*., 2023). Males have more physique and muscle mass tan women, making it possible to carry out farming activities such as hoeing, lifting crops, and digging the soil. Women focus on homemaking and looking after their children at home. Farmers have been working for over ten years for the following reason: on average, farmers are land owners and managers of their crops which explain the urge to work as farmers for a long time. Similar research also reveals that farmers range from productive to old age (Malaj *et al*., 2020). In rural areas, people of productive age who remain physically strong will work professionally. Elderly farmers will only monitor and evaluate the process of managing agricultural land and crop yields.

This study found that 78% of farmers in Jonggol Village experienced health problems due to pesticide use (Table 3). Its results align with previous research, which found that 71.4% of farmers were aware of the emergence of health problems (Alex *et al.*, 2018). However, The research of Edwin *et al.* (2021) produced the following contrasting finding: 60% of farmers stated that they did not experience health problems. In another research, Edwin *et al.* (2021) found that of the 40% of farmers who admitted to experiencing health problems, more than 50% experienced respiratory problems. The findings of Edwin *et al*. (2021) are in line with research that the majority of farmers (74.7%) experience respiratory health problems (Table 3). Improper use of pesticides can cause potential respiratory health problems such as asthma, chronic bronchitis, coughing, and shortness of breath; additionally, 20% experience chest tightness (Priyadharshini *et al.,* 2017). This study also found that 44% of farmers experienced digestive health problems (Table 3). This finding aligns with the research by Tambo *et al*. (2020), who found that farmers who did not use PPE experienced digestive disorders such as nausea/vomiting, stomach cramps, and diarrhea.

Univariate analysis description of farmer behavior and health issues

Farmers in Jonggol Village had PPE at their farming headquarters during the interview and observation process. The PPE used includes protective clothing, face protection (mask), and hand protection (gloves). Some farmers do not use PPE when farming, mixing, or spraying pesticides. Farmers are also not good at maintaining personal hygiene. Table 2 shows that more than 80% of farmers do not generally use PPE. The proportion of farmers who do not use PPE is more significant than in the research by Hashemi *et al.* (2012), who found that 60% did not use PPE when using pesticides. This study found that 83.5% of farmers did not wear mouth/face protection (masks). This finding aligns with previous research by Edwin *et al*. (2021), who found that 86.67% of farmers did not use masks, as well as the research by Priyadharsini *et al*. (2017) with a proportion of 80%. Meanwhile, the proportion of farmers who did not use gloves reached 94.5%. Previous research also found that all farmers did not use hand protection (Edwin *et al*., 2021). Meanwhile, the research by Priyadharsini *et al*. (2017) found a more significant proportion of farmers who do not use gloves at 69%. The proportion of farmers who do not use protective clothing is 87.9%. This study aligns with Yuantari *et al*. (2015), who found that all farmers did not wear protective clothing and wore the same clothes for more than one day without washing them. However, the research of Priyadharsini *et al.* (2017) yields the following different finding: 65% of farmers wear unique clothing when working with pesticides; farmers who have the habit of cleaning or showering after planting account for 87.9%. This finding aligns with the research by Edwin *et al.* (2021), who found that most farmers (76.67%) showered and changed clothes after spraying pesticides. Findings related to using PPE when spraying pesticides may be related to knowledge factors that motivate or inhibit farmers' desire to use PPE. Shalaby *et al.* (2022) stated that 4.7% of farmers have limited formal education and have never attended technical training on pesticide safety. These two factors prevent farmers from understanding the dangers of warnings on pesticide labels and instructions for avoiding diseases caused by pesticides. In addition, 15.3% of farmers in this study were illiterate (Shalaby *et al*., 2022). Aspects of farmers' perceptions of pesticides are also aspects that hinder or encourage the implementation of

Table 3: Farmer characteristics in Jonggol Village in 2022

Farmers characteristics	Categories	Number (person)	Percentage (%)
Sex	Male	85	93.4
	Female	6	6.6
Age (year)	26–65	75	82.4
	≥66	16	17.6
Education level	Primary education (SD)	81	89
	Secondary education (SMP)	5	5.5
	Secondary education (SMA)	4	4.4
	Bachelor's degree (S1)	1	1.1
Length of work	Over 10 years	87	95.6
	Between 5 and 10 years	4	4.4

Table 4: Utilization of PPE and sanitary hygiene for farmers in Jonggol Village in 2022

Farmer Behavior Utilizing PPE and Sanitation Hygiene	Categories	Number (person)	Percentage (%)
Habit of not utilizing mouth/face protection (mask)	Yes	76	83.5
	No	15	16.5
Habit of not utilizing hand protection (glove)	Yes	86	94.5
	No	5	5.5
Habit of not utilizing protective clothing	Yes	80	87.9
	No	11	12.1
Habit of not bathing after farming	Yes	11	12.1
	No	80	87.9

Table 5: Farmers' health issues in Jonggol Village in 2022

Farmers' health issue	Categories	Number (person)	Percentage (%)
Emergence of farmer health issues	Yes	71	78
	No	20	22
Experiencing respiratory health issues	Yes	68	74.7
	No	23	25.3
Experiencing digertive health issues	Yes	44	48.4
	No	47	51.6

behavior to prevent pesticide exposure among farmers. Previous research found that of the three levels of perceived danger of pesticides, namely high, medium, and low, only 16.7% of farmers were found to have rated pesticides as very unsafe and not too dangerous (Hashemi *et al.,* 2012). In other words, most farmers do not think that pesticides can harm farmers. Research by Cabasan *et al*. (2019) also found that 38% of farmers consider pesticides the easiest way to control agricultural pests. Other research also found that the inconvenience of using PPE and additional costs were the main reasons for not using PPE (Lari *et al.,* 2022). This study found that using face shields (masks) was associated with health problems (Table 4). The variable habit of using mouth/face protectors (masks) has an odd ratio (OR) value of 4.24, which means that farmers who lack the habit of using mouth/face protectors (masks) will have a risk of experiencing health problems 4.24 higher than farmers who have the habit.

The results of the bivariate test become an indicator for variable selection, which is continued in the logistic regression test. The requirements for variables that will be included in the model for logistic regression testing are variables with a p-value < 0.25. Then, the analysis is repeated along with other variables that meet the requirements to enter the model. Several variables tested in the chi-square analysis in Table 5 can be included in the requirements for testing logistic regression analysis. A total of 3 variables meet the requirements to be included in the model, namely the habit of wearing face protection (mask), the habit of using hand protection (gloves), and the habit of bathing after farming.

Bivariate and multivariate analysis of farmers

This research also conducted a bivariate analysis between the dependent variable, namely health problems among farmers, and the independent variables, namely the habit of not utilizing mouth/face protection (masks), the habit of not utilizing hand protection (gloves), the habit of not utilizing protective clothing, and the habit of not bathing after farming. The bivariate analysis uses the Chi-square test. The bivariate test results show that three variables have a p-value < 0.05, namely the habit of using mouth/face protection (mask) (p-value = 0.019), the habit of using hand protection (gloves), and the habit of bathing after farming (p-value = 0.045). These three variables are related to farmers' emergence of health problems. The OR value shows the strength or weakness of the relationship between two variables (Table 6).

The study also found that as many as 68% of

Table 6: Results of Chi-Square análisis

Behavior of using PPE and hygiene individual sanitation		Emergence of health issues				Total	OR	p-value
		Yes		No				
		n	%	n	%			
Habit of Not UtilizingMouth/Face Protection (Mask)	Yes	63	82.9	13	17.1	76	4.24	0.019
	No	8	53.3	7	46.7	15		
Habit of Not Utilizing Hand Protection (Glove)	Yes	70	81.4	16	18.6	86	17.5	0.008
	No	1	20	4	80	5		
Habit of Not Utilizing Protective Clothing	Yes	9	81.8	2	18.2	11	1.31	0.548
	No	62	77.5	18	22.5	80		
Habit of Not Bathing after Farming	Yes	65	81.3	15	18.8	80	3.61	0.045
	No	6	54.5	5	45.5	11		

farmers experienced respiratory problems due to inadequate behavior in wearing masks. The study finding aligns with the research in Bangladesh that low use of PPE will increase the risk of farmer poisoning (Ali *et al.,* 2020). Health problems among farmers caused by not using face shields or masks when farming include dizziness, blurred vision, eye irritation, and excessive coughing (Tambo *et al.,* 2020). Not using a protective face mask will increase the potential exposure to toxic pesticide substances by inhalation and can cause tissue damage to the lungs, breathing difficulty, reduction in the body's immune system, and reduction in the health status of farmers and their families (ASTDR, 2017). PPE can protect the respiratory system by filtering toxic pesticide substances, thereby reducing the risk of exposure by inhalation. The study results by Zamora *et al.* (2022) in Mexico found health problems among farmers and farming families caused by not using gloves. The results of this study align with this study, which found a relationship between the occurrence of health problems and farmers' behavior in using gloves. The habitual behavior of using hand protection has an OR of 17.5, which indicates that farmers who lack the habit of using hand protection are 17.5 times more likely to experience health problems than those who use hand protection. The behavior of not using gloves is driven by low awareness of using PPE, including hand protection. The behavior of not using hand PPE (gloves) will increase dermal exposure to toxic pesticide substances and can cause tissue damage to the skin (ASTDR, 2017). The potential danger of exposure to toxic substances will occur when farmers wipe their faces or families with farmers' hands contaminated with pesticides. This behavior can become a chain of transmission of toxic pesticide substances by inhalation or oral use. This study also found that 48.4% of farmers experienced digestive disorders due to their behavior of wearing insufficient hand protection. These results align with previous research that contamination due to pesticide exposure by farmers occurs because one of them is reluctant to wear PPE, one of which is hand protection, resulting in skin contamination (Zhang *et al*., 2023). Toxic substances from pesticides in agricultural activities can be minimized by using PPE, namely hand protectors, thereby reducing the risk of exposure to toxic substances when farmers touch parts of their bodies or families. Most farmers in this study have the habit of wearing protective clothing, but the majority also experience health problems. Based on Table 4, the bivariate analysis results did not find a significant relationship between the habit of using protective clothing and farmers' health problems. The results of this study are in line with studies in several American countries that PPE masks influence exposure to pesticides that cause health problems and are less influenced by protective clothing (Paul and Ritz, 2022). Moreover, PPE use is sufficient with the use of masks, gloves, and boots; therefore, thick protective clothing does not have too much of an impact (Khuman *et al*., 2020). Based on these findings, according to ASTDR (2017), not using PPE thick protective clothing will increase dermal exposure to toxic pesticide substances and can disrupt human skin health. If the farmer meets his family and enters the house, the toxic substance will remain in the farmer's body, which could lead to a chain of transmission of toxic pesticide substances by inhalation or oral ingestion. The study also found that as many as 48.4% of farmers experienced digestive disorders. As many as 44.4% of farmers experienced digestive disorders due to the behavior of wearing protective clothing that was not thick enough; this finding is in line with the research that the use of PPE is essential in reducing exposure to toxic pesticide substances in agriculture (Zuo *et al*., 2023). Another study also found that 43% of farmers who did not wear protective clothing experienced itchy skin, and 25% felt a burning sensation (Okonya and Kroschel, 2015). Lari *et al.* (2022) explained that significant differences exist in pesticide exposure on the skin of the legs and chest; followed by the arms, face, and neck of farmers who have sprayed pesticides without PPE. Potential skin exposure values range from 0.15 to 13.45 µg. Farmers treated with PPE experienced a decrease in actual dermal exposure (ADE), %ADE, and ADEh levels than before using PPE. Thus, PPE use is the main parameter for the safety of pesticide users (Lari *et al*., 2022). Farmers in Jonggol Village are accustomed to wearing protective clothing in every farming activity, such as when spraying and mixing pesticides. This behavior can cause disease problems because wearing protective clothing without using other PPE, such as masks, gloves, and boots, still can potentially cause exposure to pesticides and health problems. Lastly, bathing behavior after farming with an OR of 3.61 shows that those who do not bathe after farming are at risk of experiencing health problems 3.61 times higher than farmers who consistently shower after farming. The results of this study align with the research in China, which found that farmers' hygiene is related to farmers' health, namely good hygiene and sanitation, which reduces the emergence of disease in farming families (Jayasiri *et al*., 2022). Not cleaning oneself can increase farmers' risk of exposure to toxic pesticide substances, which cause health problems (Lan *et al*., 2022). Bathing behavior will clean and remove pesticide chemicals when spraying and mixing pesticides, thereby reducing the dangers of pesticide exposure (Kong *et al*., 2021). Based on these findings, according to the EPA (2017), toxic pesticide substances can stick to clothes or skin by not cleaning the body after farming; such practice will contaminate farmers, and they dermally absorb the toxic substances. The study also found that 48.4% of farmers experienced digestive disorders, which is in line with research in China, namely that personal hygiene sanitation affects the health of farmers and farming families (Rousis *et al*., 2021). The condition of farmers in Jonggol Village who do not clean their bodies after bathing means that toxic substances remaining in their bodies have been absorbed into their skin tissue; thus, they metabolize to poison body tissues. Tiny particles of pesticide substances can also be inhaled by farmers or touched on farmers' bodies so that they can cause contamination. Multivariate analysis shows that the habit of using face protection, hand protection, and showering after planting has a p-value > 0.05; thus, all independent variables in the model are unrelated to farmers' health problems. The significant relationship only occurs if the type of farmer behavior is linked bivariately with the farmer's health problems. Simultaneously, all farmer behaviors are unrelated to farmer health problems (Tables 7 and 8).

This study has limitations in the study. It only focuses on looking at pesticide exposure in humans but not on when pesticides are in the environment. In fact, previous research has found a relationship between the safe use of pesticides and the perception of the dangers of pesticides to the environment, namely 79% of farmers are aware of the impact of pesticides on the ecosystem (Cabasan *et al*., 2019). The impact of pesticides on the environment can affect the concentration of pesticides that enter the human body because pesticides in water or air undergo several changing processes. Looking at the discussion from this study, Jonggol Village should be able to implement risk mitigation, such as implementing technology that can detect and monitor pesticide residues through the use of alginate-chitosan films containing Acetylcholinesterase (ACHe) and Choline Oxidase (ChO). Hermanto *et al.* (2023) developed a biosensor technology with good sensitivity, reproducibility, and stability in detecting

Table 7: Bivariate selection results

Independent variables	P-value	Explanation	Information
Habit of not utilizing mouth/Face protection (Mask)	0.019	Hypothesis 1 accepted	Enter the model
Habit of not utilizing hand protection (Glove)	0.008	Hypothesis 2 accepted	Enter the model
Habit of not utilizing protective clothing	0.548	Hypothesis 3 rejected	Not included in the model
Habit of not bathing after farming	0.045	Hypothesis 4 accepted	Enter the model

Table 8: Results of logistic regression

Independent variables	B	SE	Wald	*p-value*	OR (95%CI)	Explanation
Habit of not utilizing mouth/face protection (Mask)	-0.998	0.859	1.348	0.246	0.369 (0.068–1.986)	Hypothesis 1 rejected
Habit of not utilizing hand protection (Glove)	-2.374	1.583	2.982	0.084	0.065 (0.003–1.446)	Hypothesis 2 rejected
Habit of not bathing after farming	0.783	1.289	0.369	0.544	2.188 (0.175–2.355)	Hypothesis 4 rejected
Constant	4.335	2.257	3.689	0.055	76.319	

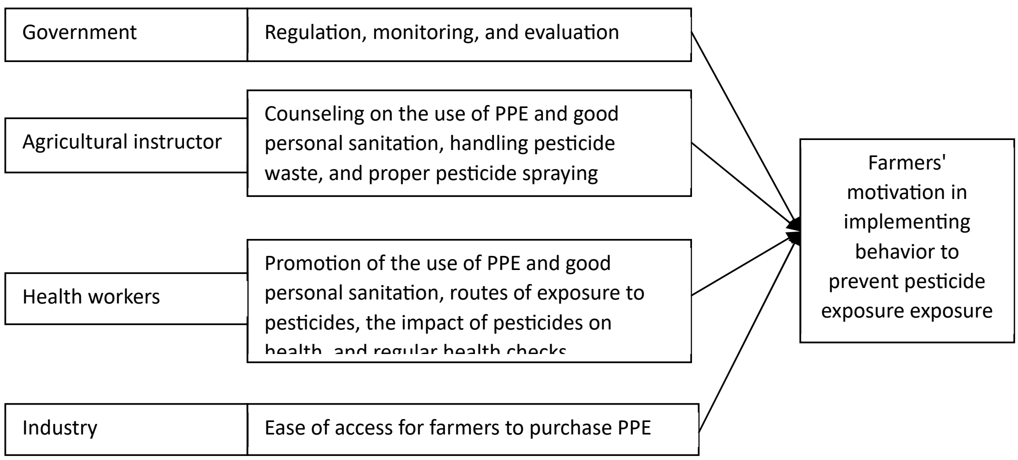

Fig. 2: Relationship between cross-sector roles and farmer motivation in implementing pesticide exposure prevention behavior

and monitoring pesticide residues. This technology is also easy to use, fast, and cheap; moreover, the analysis process can be carried out on site, thereby possibly reducing the barriers for farmers to use PPEs (Hermanto *et al.*, 2023). Increasing farmers' awareness and knowledge of using pesticides and PPE and monitoring and evaluating PPE access and availability are both essential for the government, agricultural extension workers, industry, and various agricultural sectors. Health workers can also check the health of farmers and farming families periodically so that future researchers can check pesticide levels in the blood of farmers and farming families or pesticide levels in soil, water, or air as another parameter. Fig. 2 illustrates the interrelationship of the roles between cross-sectors.

CONCLUSION

Based on the study results, 83.5% of farmers did not use mouth/face protection (mask), 94.5% did not use hand protection (gloves), and 87.9% did not use protective clothing. By contrast, most farmers behave well in terms of bathing after planting, namely 87.9%. The habit of not using mouth/face protection (mask) (p-value = 0.246), the habit of not using hand protection (glove) (p-value = 0.084), and the habit of not bathing after farming (p-value = 0.544) are insignificantly related simultaneously in overcoming farmers' health problems. Meanwhile, all three significantly have a spatial influence on farmers' health problems. The habits of not using face protection (mask) (p-value = 0.019), not using hand protection (gloves) (p-value = 0.008), and not showering after planting (p-value = 0.045) have a real impact on farmers' health problems. Farmers who do not use face and mouth protection are 4.24 times more likely to experience health problems than those who do. The behavior of not bathing after farming is 3.61 times more likely to experience health problems than the opposite. The behavior of not using hand protection (gloves) partially has the most vital relationship with the emergence of health problems. Farmers who do not use hand protection (gloves) are

17.5 times more likely to experience health problems than those who use gloves. The habit of not using protective clothing is not related to health problems (p-value = 0.548). As many as 78% of farmers stated that they had health problems, 74.7% experienced respiratory health problems, and 48.4% experienced digestive health problems. These findings demonstrate the importance of in-depth epidemiological studies of specific environmental factors and pesticide exposure pathways that cause farmer health problems. This study has limitations and also guides future research. Although this study discusses the habitual behavior of using PPE, farmer hygiene, and sanitation regarding farmer health problems, this study is limited to one village in West Java Province, namely Jonggol Village. Further research on farmer behavior and health issues should be conducted to assess exposure to environmental pesticides and their toxic substances in the human body, which could contribute to expanding research results. Future research should conduct qualitative studies through in-depth interviews or Focus Group Discussions, which can contribute to increasing the strength of the relationship between farmer health disorders and building the health of farmer families and the surrounding community. Another form of intervention is designing and implementing programs in collaboration with agricultural extension workers, health workers, and local community leaders using a persuasive approach.

AUTHOR CONTRIBUTIONS

G. Fizulmi permorfed the results, prepared the manuscript text, and manuscript edition. H. Agustina performed the data analysis, prepared all the maps and figures, and interpretation of the results.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

>	More than
≥	More than or equal to
<	Less than
%	Percent
%ADE	Percentage of actual dermal exposure
μg	Micrograms
ACHe	Acetylcholinesterase
ADE	Actual dermal exposure
ASDR	Agency for toxic substances and disease registry
ChO	Choline oxidase
e	Degree of tolerance for inaccuracy in retrieval sampel
FAO	Food and agriculture organization
ha	Hectare
km	Kilometer
M	Meter
OR	odd ration
N	Total farming population by village

n	Total of samples taken for research
N95	Non-oil 95 (N95)
PPE	Personal protective equipment
p-value	The probability under the assumption of no effect or no difference
S1	Strata 1 (Bachelor degree)
SD	*Sekolah dasar* (elementary school)
SMA	*Sekolah menengah atas* (senior high school)
SMP	*Sekolah menengah pertama* (junior high school)
SPSS	*Statistical package for the social sciences*

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