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Application of Structural Equation Model-Partial Least Square for Factors Affecting the Risk of Pesticide Poisoning

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A B S T R A C T

The health belief model is used as a framework to identify factors that influence the risk of pesticide poisoning. Research on the factors that influence knowledge and behavior to reduce pesticide exposure using the Health Belief Model and the Structural Equation Model – Least Square has been conducted. This study aims to analyze the effect of the health belief model in predicting behavior to reduce the health impact of pesticides. This type of research is an analytic observation with a cross-sectional design. Structural Equation Model – Least Square is partly an approach used to determine latent variables with bootstrap parameter estimation. The results showed that all latent variables had an effect on farmers' self-efficacy. Increasing the farmer's self-efficacy by 1% can reduce the level of poisoning by 81.3%. Farmers must be able to increase their self-efficacy regarding the risk of pesticide exposure and implement safe pesticide use procedures.

A B S T R A K

Model kepercayaan kesehatan digunakan sebagai kerangka kerja untuk mengidentifikasi faktor-faktor yang mempengaruhi risiko keracunan pestisida. Penelitian tentang faktor yang mempengaruhi pengetahuan dan perilaku untuk mengurangi keterpajanan pestisida dengan Model Kepercayaan Kesehatan serta Model Persamaan Struktural – Kuadrat Terkecil Sebagian belum pernah dilakukan. Penelitian ini bertujuan untuk menganalisis pengaruh model kepercayaan kesehatan dalam memprediksi perilaku petani untuk mereduksi dampak kesehatan akibat keterpajanan pestisida. Jenis penelitian ini merupakan observasi analitik dengan rancangan potong lintang. Model Persamaan Struktural – Kuadrat Terkecil Sebagian merupakan pendekatan yang digunakan untuk mengetahui hubungan variabel-variabel laten dengan estimasi parameter bootstrap. Hasil penelitian menunjukkan bahwa seluruh variabel laten berpengaruh terhadap efikasi diri petani. Peningkatan efikasi diri petani sebesar 1% dapat menurunkan tingkat keracunan sebesar 81.3%. Petani harus bisa meningkatkan efikasi diri tentang risiko keterpajanan pestisida dan melaksanakan prosedur penggunaan pestisida yang aman.

INTRODUCTION

Pesticide poisoning is a global public health problem. The World Health Organization (WHO) estimates that about one million cases of pesticide poisoning have caused about 20,000 deaths each year since 1990. Thirty years later there is no current picture of global pesticide poisoning despite increasing global pesticide use. As many as 44% of farmers of the 860 million agricultural population in the world have been exposed to pesticides. WHO reports that the average death rate from poisoning reached 1.4 per 100,000 population in 2016 (WHO, 2019 ; Boedeker et al., 2020). The Food and Drug Information and Data Center for the Food and Drug Examination Agency in 2019 reported that there were 147 cases of poisoning caused by agricultural pesticides in Indonesia. There were 190 cases of poisoning for men and 144 for women. There were 90 cases of pesticide poisoning in Central Java Province in 2019 (BPOM, 2019) .

A cohort study conducted on land in Andalusia, Spain, showed that pesticide agricultural pesticides trigger liver damage, which is one of the stages of liver injury. The enzyme metabolism of these pesticides causes susceptibility that can harm health (Hernández et al., 2013). Several research results show that there is a relationship between pesticide pesticides and the incidence of several diseases including bladder cancer, colon cancer, meningiomas, brain tumours, breast cancer, asthma, type 2 diabetes, parkinsonism, acute lymphoblastic leukaemia, neurological diseases and hypospadias (Kim et al., 2017).

The use of synthetic pesticides has created a dilemma. Synthetic pesticides, on the one hand, can improve human well-being, but on the other hand, pesticides are poisons that damage humans and the environment. In some cases of pesticide poisoning, farmers and other agricultural workers are exposed to pesticides in the process of mixing and spraying pesticides. In addition, the community around the agricultural location is very at risk of being exposed to pesticides. Inappropriate use of pesticides in Brebes Regency, Central Java, harms human health such as headaches, eye irritation, nausea and itchy skin (Mahmudah et al., 2012). The results of previous studies showed that the shallot production area in Wanasari District, Brebes Regency contained several types of insecticides and fungicides that were used in each growing season. Farmers apply large amounts of pesticides every three or four days. Farmers mix at least three types of insecticides and fungicides about 30–40 mL for each type. The organophosphates found in the soil samples included methidathion around 0.014 mg/kg, malathion 0.1370-0.3630 mg/kg, and chlorpyrifos 0.0110-0.0630 mg/kg. Excessive pesticide application shows the potential for land pollution (Joko et al., 2017).

Measurement of acetylcholinesterase (AChE) activity is the main biomarker in cases of poisoning or exposure to organophosphate pesticides. Acetylcholinesterase blood is used to combine exposure to organophosphate and carbamate pesticides. The results of several previous studies showed that there was a significant relationship between exposure and symptoms of chronic pesticide toxicity with acetylcholinesterase activity in humans (Araoud, 2011).

The Health Belief Model (HBM) can explain the prevention behaviour and individual response to disease. The HBM asserts that a person's perception of susceptibility and efficacy in treatment can influence a person's decisions about his or her health behaviour. The principle of HBM theory is that health behaviour is motivated by four factors, namely perceived susceptibility, perceived severity, perceived benefits and perceived barriers to action (Nurhandiya et al., 2020). According to HBM, farmers must have a mindset about their susceptibility to disease (perceived susceptibility) and consider disease as a serious threat (perceived severity), farmers have confidence that healthy behaviour is very useful for health (perceived benefits), and farmers have confidence that being healthy comes at a high cost (perceived barriers). Self-efficacy is an additional component in the HBM. Self-efficacy plays a role in building farmer behaviour in handling pesticides (Bay & Heshmati, 2016). HBM is a cognitive model that can explain and predict farmer behaviour in using pesticides (Sookhtanlou & Savari, 2020).

Structural equation modelling is one of the best analytical techniques because it can analyze and interpret the direct and indirect relationships between independent variables and dependent variables (Abdollahzadeh et al., 2017). Study on factors influencing knowledge and behaviour to reduce pesticide exposure with the Health Belief Model and Structural Equation Modelling – Partial Least Square has never been conducted. This study aims to analyze the effect of HBM in predicting behaviour to reduce the impact of pesticide exposure.

METHOD

Location

Research location in Brebes Regency of Central Java Province. Location determination considers the level of onion production with high, medium and low classification. Three sub-districts were selected from 12 onion producing sub-districts, namely Brebes, Jatibarang and Wanasari.

Characteristics of Research Subjects and Research Design

This type of research is an analytic observation with a cross-sectional design and implementation from November 2020 to December 2020. The primary data used in this study includes the cholinesterase activity of shallot farmers and the perceptions and behaviours of shallot farmers. Secondary data was obtained from scientific articles obtained in several national scientific journals and international journals.

Sample Size

Determine the sample size using the hypothesis test formula for a single population. The minimum sample size taken in this study can be calculated based on the sample size of one population) with the following equation:

$$n = \frac{Z^2{}_{1-\alpha/2} P(1-P)}{d^2}$$

n = the required sample size ;
Z = standard value of normal distribution in degrees 95% confidence($Z_{1-/2}$ = 1.96) ;
P = Proportion of population exposed to pesticides (P = 0.566)
D = Absolute precision (number of people that must be included in the sample so that prevalence can be exceptional within 15% (0.15) above and below the true prevalence with a level of 95% confidence (Charan & Biswas, 2013 ; (X. Wang & Ji, 2020) .

The minimum sample size is:

$$n = \frac{(1{,}96)^2 (0{,}566)\,(1-0{,}566)}{(0{,}15)^2} = 42$$

The minimum sample size to be taken in this study is 42 people/respondent. Based on these calculations, a minimum sample size of 45 samples was obtained (Charan & Biswas, 2013) .

Sampling Procedure

The sampling technique used is purposive sampling. Respondents residing in the Districts of Brebes, Wanasari and Jatibarang found 135 people. One village was selected for each sub-district. Three groups of farmers were selected from each village and 15 farmers were selected from each farmer group. The inclusion criteria of the respondents consisted of 1) Male; 2) Domiciled in the research area; 3) working as a shallot farmer for more than five years; 4) spraying and being a respondent (UNDP, 2011; W. Wang et al., 2017).

The researcher explains the agreement after explaining the research to be carried out. The collection of cholinesterase activity test data was carried out and descriptive data on the health of respondents by medical laboratory technicians, Cito Clinical Laboratory, Tegal City. Meanwhile, the researchers studied the exogenous and endogenous latent variables of farmers which were carried out by themselves. The latent variable interview questions have five questions, including "strongly disagree", "disagree", "abstain", "agree", and "strongly agree" using a Likert scale ranging from 1 value for negative perception answer to 5 value for positive perception answer (Berni et al., 2021). All data using the health confidence model (HBM) and partial least squares structural equation modelling (PLS-SEM) using the SmartPLS 3 software (Leguina, 2015) .

Research variable

The research variables used consisted of four exogenous latent variables: 1) perceived susceptibility, 2) perceived severity, 3) perceived benefits, 4) perceived barriers) and two endogenous latent variables: 1) self-efficacy and 2) toxicity level. (Suratman et al., 2016) . Exogenous and endogenous latent variables were described in the table below:

Table 1
Exogenous Latent Variables and Endogenous Latent Variables

No	Exogenous Latent Variables	Indicator	Symbol
1	Perceived susceptibility	Pesticide exposure does not cause adverse effects on health.	KR_1
		Farmers sometimes experience organophosphate pesticide poisoning.	KR_2
		Human skin is not the entrance for organophosphate pesticides into the body.	KR_3
		Pesticides are harmless to the human body.	KR_4
		Pesticides are harmless if not ingested.	KR_5
		Organophosphate pesticides can be neutralized by the liver if they enter the body.	KR_6
2	Perceived severity	If the pesticide gets on the skin, it will only cause mild effects and recover soon.	KP_1
		Organophosphate pesticides only cause itchy skin.	KP_2
		Diseases caused by the use of organophosphate pesticides are cured.	KP_3
		There are marks on the skin after spraying with organophosphate pesticides in rice fields are not dangerous.	KP_4
3	Perceived benefits	The use of personal protective equipment will protect the body from the effects of organophosphate pesticides.	MF_1
		The use of personal protective equipment is useful for health maintenance	MF_2
4	Perceived barriers	The use of personal protective equipment when spraying organophosphate pesticides is very inconvenient.	HB_1
		The price of personal protective equipment is very costly.	HB_2
		The use of personal protective equipment causes feelings of discomfort	HB_3
		If farmers carry out safe procedures in spraying pesticides, it will cause additional time.	HB_4
	Endogenous Latent Variables	Indicator	Symbol
1	Self efficacy	Health workers advise using personal protective equipment.	IB_1
		I suffer because I don't follow safe procedures when spraying organophosphate pesticides.	IB_2
		My body feels itchy after being sprayed with organophosphate pesticides.	IB_3
		I have a headache after spraying organophosphate pesticides.	IB_4
		I don't understand the symptoms of pesticide poisoning.	IB_5
2	Poisoning level	Organophosphate pesticide poison strata	KL

RESULT AND DISCUSSION

The sample size is 45 respondents for each district of Brebes, Wanasari and Jatibarang. Table 2 shows that abnormal of pesticide poisoning is high in the Brebes and Wanasari sub-districts. Dry throat, burning nose and constipation are on average high in the Jatibarang sub-district. Wanasari District with a high incidence of chest pain, numbness, shortness of breath, stomach pain and sore throat. Headaches, muscle cramps and constipation are occurrences with a high average in the Brebes sub-district.

Table 2
Respondents' Health Level in Brebes, Jatibarang and Wanasari Districts

Criteria	Category	Brebes n=45 (%)	Jatibarang n=45 (%)	Wanasari n=45 (%)
Poisoning level	Normal	19 (42.22)	23 (51.11)	19 (42.22)
	Abnormal	26 (57.78)	22 (48.89)	26 (57.78)
Dry throat	Yes	2 (4.44)	4 (8.89)	2 (4.44)
	No	43 (95.56)	41 (91.11)	43 (95.56)
Pain chest	Yes	3 (6.67)	3 (6.67)	5 (11.11)
	No	42 (93.33)	42 (93.33)	40 (88.89)
Numb	yes	2 (4.44)	2 (4.44)	4 (8.89)
	no	43 (95.56)	43 (95.56)	41 (91.11)
Breathless	yes	4 (8.89)	6 (13.33)	6 (13.33)
	no	41 (91.11)	39 (86.67)	39 (86.67)
Headache	yes	7 (15.56)	4 (8.89)	6 (13.33)
	no	38 (84.44)	41 (91.11)	39 (86.67)
Stomach ache	yes	2 (4.44)	1 (2.22)	3 (6.67)
	no	43 (95.56)	44 (97.78)	42 (93.33)
Sore throat	yes	3 (6.67)	4 (8.89)	5 (11.11)
	no	42 (93.33)	41 (91.11)	40 (88.89)
Burning nose	yes	2 (4.44)	3 (6.67)	2 (4.44)
	no	43 (95.56)	42 (93.33)	43 (95.56)
Muscle cramp	yes	1 (2.22)	0 (0)	0 (0)
	no	44 (97.78)	45 (100)	45 (100)
Constipation	yes	2 (4.44)	2 (4.44)	1 (2.22)
	no	43 (95.56)	43 (95.56)	44 (97.78)

Model Size

SmartPLS 3 application to analyze the structural relationship between perceived susceptibility, perceived severity, perceived benefits, perceived barriers, self-efficacy and toxicity level. The process of validating latent variables and indicators aims to develop a measurement model. The next step is hypothesis testing to estimate the relationship between latent variables in the structural model (Leguina, 2015) .

Convergent validity is utilised to measure the size of the indicator that can explain the latent variable. If the value of convergent validity is higher, the indicator's ability to explain latent variables is greater. The standardized loading factor value on the variables of each main indicator is used to assess the validity of the indicator. A loading factor value greater than 0.7 can be interpreted as a correlation with convergent validity (Leguina, 2015)

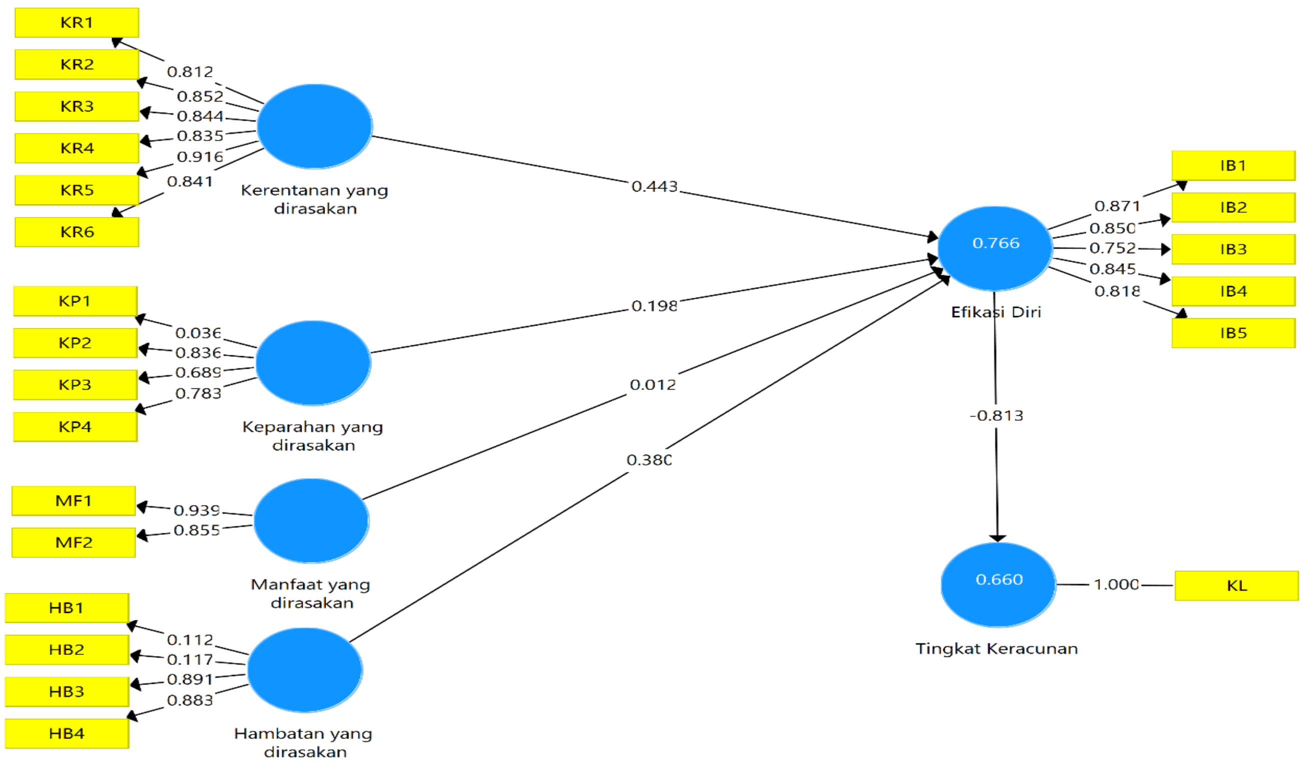

Figure 1. Path diagram with loading factor value

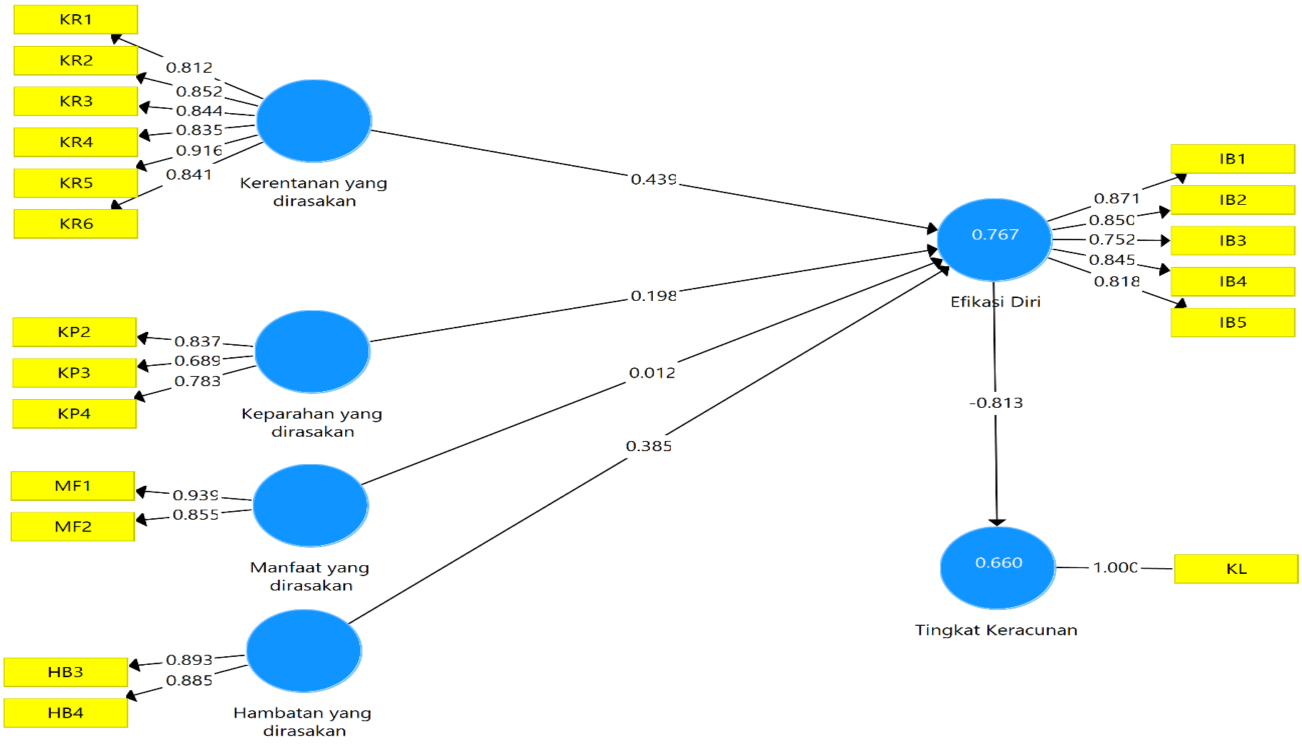

Figure 2. Path diagram with loading factor value after the indicator is eliminated

Table 3
Average Variance Extracted Value and Composite Reliability on each Latent Variable

Latent Variable	Average Variance Extracted	Composite Reliability
Perceived barriers	0.79 0	0.882
Self efficacy	0.686	0.916
Perceived severity	0.596	0.816
Perceived susceptibility	0.723	0.940
Perceived benefits	0.806	0.892
Poisoning level	1	1

Based on Figure 1, the indicators KP_1, HB_1 and HB_2 must be eliminated from the model because they have a loading factor value below 0.7. Figure 2 shows the results of structural models with standard values of loading factors resulting from the removal of invalid indicators (Leguina, 2015).

Results based on the analysis in table 3, the average variance extracted variance value for all variables is greater than 0.5. It means that the latent variable already has good *convergent validity* with the latent variable being able to explain the average of more than half the variance of the indicators. All latent variables have a composite value of more than 0.7. It can be interpreted that all latent variables are reliable.

Structural Model

The structural model is a model that connects exogenous latent variables (X) with endogenous latent variables (Y) or the relationship of endogenous variables (Y) with other endogenous variables (Y). The assessment of this relationship uses path coefficients, evaluation of predictive relevance (Q^2) and goodness of fit (GoF). The structural model in this study consisted of four exogenous latent variables and two endogenous latent variables. The path coefficient values and t-statistic values are found in the bootstrapping process with a sample size of 135 for resampling and 5000 repetitions (Leguina, 2015).

Table 4
Result of Direct Effect of Path Coefficient of Structural Model

	Average	Standard Deviation	t- Statistics	*p value*
Perceived barriers -> self-efficacy	0.385	0.062	6.214	0.000 *
Self-efficacy -> level of pesticide poisoning	-0.811	0.028	29.252	0.000 *
Perceived severity -> self-efficacy	0.198	0.043	4,561	0.000 *
Perceived susceptibility -> self-efficacy	0.441	0.057	7.728	0.000 *
Perceived benefits -> self-efficacy	0.017	0.034	0.339	0.000 *

*) $p < 0.05$

The hypotheses in this study are as follows:

H_1 : There is a positive influence of perceived susceptibility on self-efficacy.

H_2 : There is a positive influence of perceived severity on self-efficacy.

H_3 : There is a positive influence of perceived benefits on self-efficacy.

H_4 : There is a positive influence of perceived barriers on self-efficacy.

H_5 : There is a positive influence of self-efficacy on reduction rate of pesticide poisoning.

Based on the direct influence of the path coefficients of the structural model in table 4, it can be said as follows:

1. The perceived susceptibility has a significant effect on self-efficacy with an estimated coefficient of 0.441.
2. The perceived severity has a significant effect on self-efficacy with the estimated coefficient value of 0.198.
3. The perceived benefits have a significant effect on self-efficacy with an estimated coefficient value of 0.017.
4. The perceived barriers have a significant effect on self-efficacy with an estimated coefficient of 0.385.
5. Self-efficacy has a significant effect on reducing the level of pesticide poisoning with an estimated coefficient of -0.811.

Predictive relevance (Q^2)

The relevance predictive value was used to validate the model. Calculation of the predictive value of relevance using the total value of R^2.

Table 5
R^2 value on the structural model

Latent Variable	R^2
Self efficacy	0.767
Poisoning Level	0.660

The predictive value of relevance (Q^2) is written as follows:

$Q^2 = 1 - \{(1 - R^2{}_1)(1 - R^2{}_2)\}$
$= 1 - \{(1 - 0.767)(1 - 0.660)\} = 0.9211$

The value of Q^2 is 0.9211 . This means that the diversity of endogenous variables 92.11% can be explained by exogenous variables, the rest can be explained by other exogenous variables not included in the model.

Goodness of Fit (GoF)

GoF is a parameter used to validate the combined value between model measurements and model construction and show model improvements. The GoF *value was* found from the extracted mean-variance multiplied by the R^2 value. The GoF *values of* 0.1, 0.25, and 0.38 respectively indicate that the model is considered poor, moderate and good (Leguina, 2015).

Table 6
The Goodness of Fit Value

Latent Variable	Average Variance Extracted	R^2
Perceived barriers	0.790	
Self efficacy	0.686	0.767
Perceived severity	0.596	
Perceived susceptibility	0.723	
Perceived benefits	0.806	
Poisoning Level	1,000	0.660
Average	0.767	0.714
GoF		0.547

GoF value of 0.547 can be categorized as a good GoF because it is close to 1. It can be interpreted that the model is good at explaining empirical data.

Structural Equation Model

Structural Model 1:
Self-efficacy = 0.439*perceived vulnerability+0.198*perceived severity+0.012*perceived benefit+ 0.385*perceived resistance

Structural Model 2:
Poisoning rate = -0.813*self-efficacy

Based on the first structural equation model, an increase in perceived vulnerability of 1% can increase self-efficacy by 43.9%; an increase in perceived severity of 1% will increase self-efficacy by 19.8%; an increase in perceived benefits of 1% will increase self-efficacy by 1.2%; an increase in perceived barriers of 1% it will increase self-efficacy by 38.5%.

In the second equation model, it can be said that an increase in self-efficacy of 1% can reduce the level of poisoning by 81.3%. Results Based on the analysis, perceived benefits can increase self-efficacy. This is in accordance with the research results of Bhandari et al. (2018) that perceived benefits affect farmers' self-efficacy (Bhandari et al., 2018). The results of research by Yuantari et al. (2015) showed that self-efficacy (use of personal protective equipment) can help maintain the health of farmers from pesticide poisoning. Perception of damage due to the use of pesticides affects self-efficacy. Farmers who have experienced pain in working with pesticides have a perception of severity and a desire to build self-efficacy. Farmers learn from personal experience (Sharifzadeh et al., 2019).

The perception of vulnerability affects the self-efficacy of farmers. The more vulnerabilities that are felt, the higher the self-efficacy towards the safe use of pesticides. This is in accordance with the results of the study (Bhandari et al., 2018) . Perceived barriers in this study have an influence on self-efficacy. Farmers benefit from the price of personal protective equipment (PPE) which is expensive and does not match their income. Therefore, farmers have self-efficacy not to get economic benefits (Yuantari et al., 2015).

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High self-efficacy in pesticide-using farmers is a high level of self-confidence, a high level of motivation in the practice of reducing health impacts due to pesticide use (Pasiani et al., 2012). The results of the analysis in this study indicate that an increase in self-efficacy by 1% will reduce the level of poisoning by 81.3%. The results of research by Yuantari et al. (2015) showed that self-efficacy can help maintain the health of farmers from pesticide poisoning. The results showed that the level of pesticide poisoning was influenced by perceptions, attitudes, and self-efficacy (Mahyuni et al., 2021).

CONCLUSION AND RECOMMENDATIONS

Perceptions of perceived susceptibility, perceived severity, perceived benefits and perceived barriers affect farmers' self-efficacy. Having susceptibility has the most influence on increasing self-efficacy. Increasing self-efficacy by 1% can reduce 81.3 % of the level of poisoning.

Suggestions for future research, larger samples should be more so that the resulting model is more suitable. The knowledge and the belief about the dangers of pesticide pesticides to minimize the health impacts of using pesticides.

Ethics Committee

The ethical permit has been approved by the Research Ethics Committee Involving the Subjects of the Bogor Agricultural University with the number: 245/IT3.KEPMSM-IPB/SK/2019 dated October 30, 2020.

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Conflict of Interest Statement

The author declares that there is no conflict of interest associated with the authorship and publication of this research article.

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