

# Factors Influencing Compliance to Safety Measures in Pesticide Use among Small-scale Farmers in Miryia Subcounty, Masindi District, Uganda

## ABSTRACT

There is a global challenge mainly manifested in developing economies where compliance to safety measures in the use of pesticide especially by farmers is very low resulting in health challenges. This study therefore aimed at assessing the determinants of compliance to safety measures in the use of pesticide among local farmers in Miirya Sub County of Masindi District, Uganda. The objectives of the study were to identify the individual and institutional determinants related to compliance, then establish the level of compliance and finally determine the association between the different factors and compliance to safety measures in the use of pesticides among small scale farmers.

Systematic random sampling was used to select the respondents, and a research-administered questionnaire was used to collect data. Data were analysed using both descriptive and inferential

**Commented [MOU1]:** The abstract is quite detailed, but some sentences could be made more concise, especially in the results section. For example, the list of demographics could be shortened or only the most relevant details mentioned. Some phrases, such as "compliance to safe measures in the use of pesticides among farmers" could be simplified for readability, perhaps as "compliance with pesticide safety measures."

statistics, at 95% level of significance. Chi square analysis and binary logistic regression analysis were used to test for significance.

The study found that the level of compliance to safe measures in the use of pesticides among farmers was low (30.2%). Findings also showed that the majority of the respondents were 40 years and above (66.7%), primary graduates (61.8%), married (84.0%), high knowledge level (94.8%), negative attitudes towards safe use of pesticides (70.8%), high risk perception (91.7%), no influence of peers (57.9%), using pesticide toxicity classes II and III (66.7%), never been trained on PPEs (53.2%), never received inspection in the past year (70.5%), and SOPs in place (81.4%). The bivariate logistic regression analysis indicated that farmer's attitude; risk perception and standard operating procedures (SOPs) in place were significantly associated with compliance to safe measures in the use of pesticides among farmers ( $p < 0.05$ ).

The most significant factors influencing compliance among the local farmers are attitude, risk perception and SOPs. Once the above are targeted there is bound to be a positive change in the adherence to safety measures. The study therefore recommends that there is need for local farmers to be made aware of the risks attached to improper use of pesticides and the reinforcement of provisions and adherence to standard operating procedures by the relevant authorities.

**Keywords:** Compliance to safe use of pesticides; small scale farmers; agricultural pesticides.

## 1. INTRODUCTION

Globally, the use of pesticide is growing day by day, but the adequate compliance to safety measures of pesticide use in developing economies is still low and farmers are directly exposed to chemicals which have a negative impact on their health [1]. It is estimated that every year there is a 50 – fold increase in global pesticide consumption; and 2.5 million tons of pesticides are used each year; out of which about 69% is used in Europe and the US alone [2,3,4]. However, Miller et al, [5] reported earlier that every year the pesticides used by farmers are 10 - 100 times more toxic than those used in the previous year. They further noted that over 80% of farmers worldwide do not comply to the safety measures of handling these pesticides [5]. These statistics are however assumed to be even higher in developing countries. In addition, in developing countries, concerns about the adverse effects of pesticide on health are increasing, especially because of low educational level and unfavourable working conditions. A study in Kuwait revealed that over 70% of the farmers were not compliant to the standard safety measures of pesticide use, for example, they did not read or follow pesticide label instructions [6]. In Vietnam, non-compliance to safe pesticide measures was found to be 67% [7]. Countries like Nepal, despite the fact that pesticide consumption is increasing by about 10%–20% per year adherence levels to safe measures of pesticide use is very low at 15% [8].

In Africa, despite the popularity and extensive use of pesticides, there are noted serious

concerns about health risks arising from the exposure of farmers when mixing and applying pesticides or working in treated fields and from residues on food and in drinking water for the general population [9]. Problems caused by pesticides are as a result of excessive, unscientific, and ineffective applications, which have resulted in residue on agricultural products, increased production costs, and environmental pollution [10]. In a number of African countries, pesticide use has been noted with attached health impacts on the farmers, attributed to non-compliance to safety measures of pesticide handling [11]. For example, in Ghana, Afari-Sefa et. al., [12] reported that farmers experienced health impacts of pesticides after application. They were further reported not taking into consideration health protection when applying the pesticides. According to this scholar, the level of adherence to safety measures of pesticide use was found to be as low as 11%. Similarly, Kwadzo et. al., [13] also noted that farmers in Nigeria were exposed to health risk factors of skin/eye irritation due to inadequate knowledge on personal protective equipment use during pesticide application; while those who had some training and education on pesticide usage had low levels of health effects.

In East Africa, the problem of compliance to safety measures of pesticide handling is almost the same. For example, in Tanzania, it was established that about one-third of the farmers applied pesticides in mixtures of various doses, and about 68% of the farmers reported having felt sick after routine pesticides application [14,15]. While in Rwanda, it is noted that over

**Commented [MOU2]:** In this introduction, the background of the research, objectives, and gaps that occur have been explained. However, it is necessary to add an explanation of the benefits of conducting this research both for the community of pesticide users and for the relevant government in responding to pesticide problems in the community.

95% of farmers do not comply with minimum standards for safe pesticide use and 80% of farmers store pesticides in their homes without personal protection measures [16,17].

Several factors have been identified in previous investigations associated with farmers' pesticide exposure. Some of these factors include the lack of use of appropriate equipment along with taking protective activities that are needed during pesticide handling, insufficient knowledge of the law, and lack of training [18]. Other scholars like Khanal & Singh [8] identified institutional determinants like pesticide toxicity class, training of farmers on PPE, inspections by agricultural officers, standard operational procedures in place and accessibility to PPE as among those factors associated with compliance to safe measures of pesticide use [19].

In Uganda, unlike the practice in several other developing countries, small-scale farmers do not use the most hazardous pesticides of WHO class 1a and 1b. However, the use of WHO class II pesticides and those of lower toxicity is seen in combination with inadequate knowledge and practices in safe use of pesticides among the farmers [20,21]. These pose a danger of acute intoxications, chronic health problems and environmental pollution. Therefore, training of farmers in IPM methods, the practicing of proper hygiene and the use of personal protective equipment (PPE) when handling pesticides should be promoted [22]. Unfortunately, no study has been done to document the level of compliance to safe measures of pesticide use in this part of Uganda. It was therefore necessary to conduct a study on the compliance to safe measures in use of pesticides among farmers.

### 1.1 Brief Literature Review and Identified Gaps

The literature was reviewed regarding a number of variables related to compliance to safe measures of pesticide use among farmers. The variables that guided the review included age of respondent, level of education, marital status of respondent, knowledge, attitude, risk perception, pesticide toxicity class, training of farmers on PPE, inspections by agricultural officers, standard operational procedures in place and accessibility to PPE. A number of gaps were identified in the review, as summarised below.

A recent scholar used the theory of planned behaviour which does not address the time frame between "intent" and "behavioural action" [23]. The current study hence adopted health belief model, to cater for the influence of institutional factors and the individual behaviour issue solved.

Regarding sample size determination, some scholars used the expected frequency of 50% to determine the sample size [24], being that the target population was unknown, and current study used Cochran formula to determine the sample size since the target population is known/definite. Some scholars used a significance level of 1% [25], hence a need to do another study adopting a significance level of 5%.

When looking at study subjects, some scholars only focused on rice growers [26], only arable crop farmers [27], some only focused on maize farmers [28], some only considered on farm workers on the palm oil plantations [29], some focused on vegetable farmers only [30], some conducted the studies among pesticide retail firms [31] other than the farmers who are the primary users of these pesticides. The current study included all farmers regardless of what they specialized in growing/ farming.

On the data collection processes, some scholars used in-depth interviews and observations on-farm to collect the data from the farmers [6,27], and left out the quantitative data which would have been used to obtain statistical evidences of the intriguing factors associated with compliance to safe measures of pesticide use; and some scholars used focused group discussions and pre-test surveys, to collect data from the respondents [32], which could only be appropriate in gathering qualitative data but not quantitative data.

In reference to data analysis, some scholars used correlation analyses to establish the existing relationships occurring between the response and explanatory variables [33]; some scholars used correlation analyses [34] to establish the existing relationships occurring between the response and explanatory variables. Some scholars analysed the data in the study using only descriptive analyses [26], which could not clearly establish the statistical significance existing between the different independent variables and safe measures of pesticide use. Since the current study has only categorical variables, it hence used chi square analysis/

Fisher's exact test and binary logistic regression model.

The current study therefore focused at bridging the identified gaps above, to assess the determinants of compliance to safe measures in the use of pesticide among farmers in Miirya Sub County, Masindi District.

## 1.2 Statement of the Problem

Pesticides have become an integral part of present-day farming, and play a major role in increasing agricultural productivity [10]. However, the indiscriminate and extensive use of pesticides represents one of the major environmental and public health problems all over the world, and this is due to noncompliance to safe use of pesticides. Despite the vast interventions put in place by the government of Uganda through the ministry of agriculture, including training of farmers at local level about safe measure of pesticide use this problem has remained existing in the region In Uganda, compliance to safe measures of pesticide use is still very challenging, while compliance to safe measure of pesticides in Uganda is up to 48%. [35]. In Masindi including Miirya sub county, compliance level is far below at 9% [21]. Inappropriate application of pesticides can have negative effects on human health [33]. Despite the vast interventions put in place by the government of Uganda through the ministry of agriculture, including training of farmers at local level about safe measures of pesticide use, this problem has remained existing in the region [35,36]. It is therefore not clear whether pesticide knowledge, attitude, level of education risk perception among the farmers has a resultant effect on farmers compliance to safe measures in the use of pesticides among the farmers, thus a need for research.

The aim of this study was to assess the determinants of compliance to safe measures in the use of pesticides among farmers in Miirya Sub County, Masindi District, Uganda. Specifically, the objectives of this study were to:

- identify the different factors related to compliance to safe measures in the use of pesticides among farmers in the sub-county;
- establish the level of compliance to safety measures in the use of pesticides among farmers in the sub-county;

- determine the association between the different factors and compliance to safe measures in the use of pesticides among farmers.

## 1.3 Theoretical and Conceptual Framework

The study was guided by the Health Belief Model (HBM) [37]. This is a psychological model that attempts to explain why people would or would not use available services to prevent anticipated future complications arising because of neglected services prior to the complication.

Although HBM is considered for this study of compliance to safe measures in the use of pesticides, the model does not address certain individual and institutional factors. Using this theoretical frame work, however, a conceptual framework was developed underpinning this study.

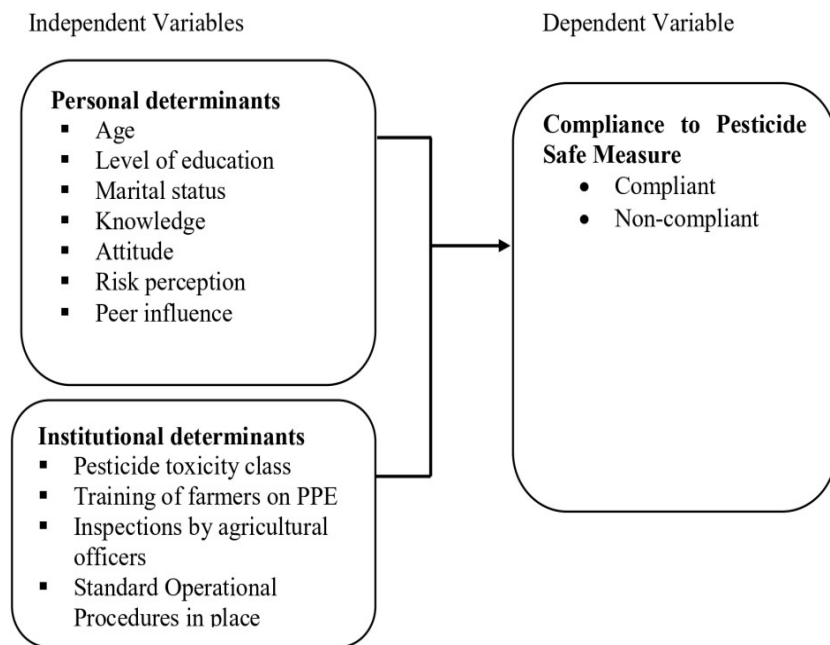
The logic underlying the dependent variable in this analysis is that safety practices is a function of set of independent variables. A conceptual model is developed on the basis of their relationship between compliance variables and safety measure practices. The compliance factors considered in this study were the individual factor such as age, level of education, knowledge of pesticides, attitude, peer influence and risk perception. While institutional factors included trainings, pesticide toxicity class and government policy which focuses on guidelines and enforcements. These in the ideal situation can affect the level of compliance to safe measures in the use of pesticides thus exposure of farmers to risks associated with unsafe use of pesticides.

There are also institutional factors such as pesticide toxicity class, training of farmers on PPE, inspections by agricultural officers, standard operational procedures in place, and accessibility to PPEs.

## 2. METHODS

The researchers used a community based cross-sectional research design with a quantitative approach earlier described by Levin [38] and Setia [39], and a quantitative study approach Apuke [40] using a semi-structured questionnaire.

**Commented [MOU3]:** This method section has been explained well about the sample, sampling technique and research method using survey. However, it has not been explained what instruments are used, and how the data will be analyzed. This explanation needs to be added to complete the research method section.



**Fig. 1. Conceptual framework**

The study was carried out in Miirya sub-county, Masindi District, located in western part of Uganda. The sub-county is found in Buruli County, and it is made up of three parishes, and 36 villages. The parishes in Miirya sub-county are Bigando, Isimba and Kigulya, and the sub-county is bordered by Kimengo sub-county in the south, Nyangahya sub-county in the south west, Karujubub sub-county in the North West, Masindi central in the west, Pakanyii sub-county in the north, and Kiryandongo district in the east. The sub-county and the entire district is made of people whose main occupation is substance farming, mainly on small scale. Since the study focuses on farmers, it was done in Mirya where the major activity is farming [41]. Many of these farmers have been enrolled on the sub county extension services that were introduced in the region by the National Agricultural Advisory Services (NAADS) and Operation Wealth Creation (OWC) in the recent past [41], which was aimed at commercialization of agriculture in the region.

According to Masindi District socio-economic report of 2020, Miirya sub-county has a total population of 4408 people [41]. This includes farmers as well as other people doing other form of work other than farming.

## 2.1 Target Population and Sample size

The target population are the farmers in Miirya sub-county in the three parishes of Bigando, Isimba and Kigulya parishes and they are 3562 farmers [41]. The majority of these farmers are carrying out substance farming on a small scale.

The Sample Size of 387 was determined using Cochran formula, which allows calculating ideal sample size given a desired level of precision, desired confidence level, and the estimated proportion of the attribute present in the population.

The sample from each parish was determined based on the proportionate sampling allocation criterion by Kothari [42].

Table 1. Sampling Frame

Parish	Total population	Population of farmers	Sample size	Households
Bigando	1651	1255	136	1439
Isimba	989	788	86	756
Kigulya	1768	1519	165	1482
Total	4,408	3,562	387	3,677

## 2.2 Sampling Procedure

In this study, systematic random sampling technique was employed to select study participants. This selected technique ensured that all respondents have an equal chance (probability) to participate in the study.

The selection of the farmers was done on household level. A sampling interval (z) was obtained by dividing the total number of farmers in Miirya sub-county by the sample size. For this study, a sampling interval of  $z = 9$  was used. This implies that after obtaining the starting respondent from the first household, every farmer found on the 9<sup>th</sup> household was selected for inclusion into the study in each of the parishes, until when the required sample size is obtained.

For households that were found having more than one respondent, a simple random sampling using raffle method was used to select only one respondent. While for cases where a household was found with no eligible respondent, the next neighbouring household was considered.

The study used a questionnaire survey method for data collection and it had both closed and open-ended questions. Measures to ensure quality included validity and reliability checks.

On top of getting relevant the institutional review board (IRB) authorization, all the required Covid 19 PPE and standard operating procedures were duly followed.

## 3. RESULTS AND DISCUSSION

A total of 387 participants were targeted and all of them responded providing 100% response rate.

### 3.1 Personal Determinants

The personal determinants related to compliance to safety measures in the use of pesticides

among farmers included age, education level, marital status, knowledge, attitude, risk perception and peer influence. Descriptive statistics were employed to analyse the data presented in Table 2.

The majority (66.7%) of the study respondents were aged 40 years and above, implying that most of the farmers who participated in the study were of older age. In contrast to study findings above, findings from another study [7], highlighted that slightly above average proportion of the farmers in the study (52.9%) were of average age bracket between 31 to 40 years. Whereas, in a similar way, a study done in Nepal about knowledge on pesticide management practices and factors associated with adoption of PPEs among farmers, revealed that the mean age of farmers who participated in the study was found to be 39.52 years, and most of the respondents were belonging to the age bracket of 36 – 50 years (41.17%) [25].

The results in Table 2 further show that the majority (61.8%) of the farmers were primary school graduates. This implies that most of the farmers in the study had low education levels. This can be attributed to the general belief in the area where it is usually assumed that individuals with higher levels of education tend to do white collar jobs, and leave farming for only those individuals with lower levels of education. Similar to study findings above, a related study in the central region of Ghana [34] found that the majority (50.7%) of farmers were primary graduates. This different from studies in Turkey [33] where the majority of the farmers (53.3%) were high school graduates.

The majority (84.0%) of the respondents were married. This is related to the fact that most of the farmers were of older age. Earlier studies [7]; Yalley 2019) in Vietnam and Ghana respectively, also showed that majority (78.2% and 72%) of the farmers were married.

Most (94.8%) of the farmers have high knowledge levels regarding safe measures of

**Commented [MOU4]:** try to check again, do the results and discussion answer the objectives of the study? There are 3 objectives that are the focus of this study which are stated in the introduction.

- identify the different factors related to compliance with safe measures in the use of pesticides among farmers in the sub-county;
- establish the level of compliance with safety measures in the use of pesticides among farmers in the sub-county;
- determine the association between the different factors and compliance with safe measures in the use of pesticides among farmers.

pesticide use. This is because the farmers in the region were given training at local level about safe measures of pesticide use. This was the same case in Ghana as reported by Miyittah et al., [34], but in Vietnam the levels of knowledge were reported to be lower (37.6%) [7,24].

Concerning attitude, most (70.8%) of the farmers have a negative attitude towards safe measures of pesticides use. This implies that most of the farmers are not very concerned about following guidelines of safe use of pesticides, like reading the precautions on pesticide labels and use of PPEs. Other earlier studies in Nigeria and China [27]. Wang and Chu [23] reported major limitations of safety practices due to poor attitude towards implementation of the safety practices.

However, a large majority (91.7%) of the farmers had a perception that there is a very high risk while using pesticides. This implies that most of the farmers had fear of acquiring the negative effects of pesticides when using them. This could have been caused by the knowledge the farmers acquired from the local trainings they received, where the trainers cautioned them against the negative effects of pesticides if improperly used. This inevitably created a high-risk perception among the farmers. These findings are similar to those earlier reported by Wang and Chu [23] in China.

It has been earlier strongly advised [43] that pesticide policies need to specifically clarify the motivation for regulation and the role of risk perceptions as far as benefit-cost analysis is concerned.

Finally on peer influence, the results (Table 2) show that the majority (57.9%) of the respondents are not influenced by their peers on the use of safe measures of pesticides. This could be because these farmers had received knowledge of pesticide use from earlier trainings, and hence it is assumed they depend on the influence of acquired knowledge from the trainings rather than influence of peers. Studies undertaken earlier in China [32], agree with the results of this study.

### 3.2 Institutional Determinants

The study also focused on the institutional factors related to compliance to safe measures in the use of pesticides among farmers. These included pesticide toxicity class, training on

personal protective equipment, receipt of inspection in the past year and SOPs in place and these are presented in Table 3.

Table 3 results show that a higher proportion (88.9%) of the farmers were using Classes I, II or III toxicity levels. This implies that most of these farmers were using relatively high hazardous pesticides. This is closely related to reports given by previous researchers in Ghana and Tanzania [28,31] respectively.

The results also show that a bigger proportion (53.2%) of the farmers had never received any training on the use of personal protective equipment (PPEs). This finding may explain why the farmers in the study had negative attitudes towards safe measures of pesticides use, since they are assumed not to know the significance of wearing PPEs and how to wear them. On the other hand, it is also likely that the negative attitudes towards safe use of pesticides might have discouraged these farmers against attending the PPE trainings. The above results are also similar to an earlier study in Malaysia by Khan et al. [29].

In the past year, the majority (70.5%) of the farmers had never received any kind of inspection on pesticide use. This implies that most of these farmers were using the pesticides without any monitoring/ inspection on whether they are following the right procedures. This also explains why most of the farmers had negative attitudes towards safe use of pesticides, since there was a gap in monitoring of compliance.

These results are in agreement with studies by Bilalib et al., (2022) and Lekeiet al., (2014) undertaken in Tanzania. They further recommended that relevant inspection personnel and policy makers should put in place programs focused towards sensitizing farmers on correct usage of pesticide and strengthen the enforcement mechanisms to improve compliance to safe pesticide management.

The majority (81.4%) of the farmers reported that they had the relevant SOPs in place (Table 3) for safe pesticide use and were using them. However earlier studies undertaken in Rwanda and Saudi Arabia [26,44] reported despite farmers having the SOPs most of the farmers were not complying with the minimum requirements of use of SOPs and in the later case they even failed to access the PPE.

**Table 2. Personal Determinants Influencing Compliance to Safety Measures in the Use of Pesticides Among Farmers**

Variables	Categories	Frequency	Percentage
Age group 45.0±11.1 year	<30years	28	7.2
	30-39years	101	26.1
	40-49years	129	33.3
	≥50years	129	33.3
Education Level	None	35	9.0
	Primary	239	61.8
	Secondary	98	25.3
	Tertiary/University	15	3.9
Marital Status	Married	325	84.0
	Unmarried	62	16.0
Knowledge Level	Low	20	5.2
	High	367	94.8
Attitude	Negative	274	70.8
	Positive	113	29.2
Risk Perception	Low Risk	32	8.3
	High Risk	355	91.7
Peer Influence	No	224	57.9
	Yes	163	42.1

**Table 3. Institutional Determinants Influencing Compliance to Safe Measures in the Use of Pesticides Among Farmers**

Variable	Categories	Frequency	Percentage
Pesticide Toxicity Class I	Class I: Bright Red, Skull-bones	86	22.2
	ClassII: Bright Yellow	133	34.4
	ClassIII: Bright Blue	125	32.3
	ClassIV: Bright Green	29	7.5
	ClassV: Flammable	14	3.6
Training on PPEs	No	206	53.2
	Yes	181	46.8
Received inspection in the past year	No	273	70.5
	Yes	114	29.5
SOPs in Place	No	72	18.6
	Yes	315	81.4



**Table 4. Chi square analysis of personal determinants associated with compliance to safe measures in the use of pesticides among farmers**

Variable	Categories	Compliance to Measures		chi-square	Df	p-value
		No	Yes			
Personal Determinants						
Age group 45.0±11.1 year	<30years	19(67.9)	9(32.1)	5.017	3	0.171
	30-39years	63(62.4)	38(37.6)			
	40-49years	90(69.8)	39(30.2)			
	≥50years	98(76.0)	31(24.0)			
Education Level	None	31(88.6)	4(11.4)	29.168	3	0.000**
	Primary	181(75.7)	58(24.3)			
	Secondary	52(53.1)	46(46.9)			
	Tertiary/University	6(40.0)	9(60.0)			
Marital Status	Married	225(69.2)	100(30.8)	0.277	1	0.599
	Unmarried	45(72.6)	17(27.4)			
Knowledge Level	Low	19(95.0)	1(5.0)	6.366	1	0.012*
	High	251(68.4)	116(31.6)			
Attitude	Negative	213(77.7)	61(22.3)	28.259	1	0.000**
	Positive	57(50.4)	56(49.6)			
Risk Perception	Low Risk	31(96.9)	1(3.1)	12.153	1	0.000**
	High Risk	239(67.3)	116(32.7)			
Peer Influence	No	197(70.1)	67(29.9)	0.026	1	0.872
	Yes	113(69.3)	50(30.7)			

**Table 5. Chi square analysis of institutional determinants associated with compliance to safe measures in the use of pesticides among farmers**

Variable	Categories	Compliance to Measures		chi-square	df	p-value
		No	Yes			
Pesticide Toxicity	ClassI: Bright Red, Skull-bones	69(80.2)	17(19.8)	11.330	4	0.023*
	ClassII: Bright Yellow	86(64.7)	47(35.3)			
	ClassIII: Bright Blue	91(72.8)	34(27.2)			
	ClassIV: Bright Green	15(51.7)	14(48.3)			
	ClassV: Flammable	9(64.3)	5(35.7)			
Training on PPEs	No	164(79.6)	42(20.4)	20.236	1	0.000**
	Yes	106(58.6)	75(41.4)			
Received inspection in the past year	No	188(68.9)	85(31.1)	0.358	1	0.549
	Yes	82(71.9)	32(28.1)			
SOPs in Place	No	70(97.2)	2(2.8)	31.611	1	0.000**
	Yes	200(63.5)	115(36.5)			

**Table 6. Multivariate Logistic Regression Analysis of Determinants Associated with Compliance to Safe Measures in the Use of Pesticides among Farmers**

Variable	Compliance to Measures		COR [ 95% CI]	p-value	AOR [ 95% CI]	p-value
	No	Yes				
Age group, 45.0±11.1 year						
<30years	19(67.9)	9(32.1)	1	1	1	1
30-39years	63(62.4)	38(37.6)	1.415[0.477-4.198]	0.532	1.392[0.470-4.119]	0.551
40-49years	90(69.8)	39(30.2)	0.810[0.269-2.435]	0.707	0.797[0.265-2.396]	0.686
≥50years	98(76.0)	31(24.0)	0.572[0.180-1.824]	0.345	0.561[0.177-1.781]	0.033
Education Level						
None	31(88.6)	4(11.4)	1	1	1	1
Primary	181(75.7)	58(24.3)	0.863[0.231-3.232]	0.827	0.814[0.220-3.017]	0.758
Secondary	52(53.1)	46(46.9)	1.984[0.476-8.266]	0.347	1.940[0.472-7.977]	0.358
Tertiary/University	6(40.0)	9(60.0)	2.665[0.397-17.870]	0.313	2.567[0.382-17.266]	0.332
Knowledge Level						
Low	19(95.0)	1(5.0)	1	1	1	1
High	251(68.4)	116(31.6)	6.789[0.462-99.843]	0.163	7.916[0.534-117.301]	0.133
Attitude						
Negative	213(77.7)	61(22.3)	1	1	1	1
Positive	57(50.4)	56(49.6)	6.057 [3.201 - 11.462]	0.000	5.247 [2.663 - 10.340]	0.000**
Risk Perception						
Low Risk	31(96.9)	1(3.1)	1	1	1	1
High Risk	239(67.3)	116(32.7)	31.271 [3.593 - 272.149]	0.002	31.507 [3.551 - 279.565]	0.002**
Pesticide Toxicity						
Class I: Bright Red, Skull-bones	69(80.2)	17(19.8)	1	1	1	1
Class II: Bright Yellow	86(64.7)	47(35.3)	1.705[0.803-3.623]	0.165	1.716[0.814-3.620]	0.156
Class III: Bright Blue	91(72.8)	34(27.2)	1.078[0.472-2.462]	0.859	1.085[0.477-2.469]	0.845
Class IV: Bright Green	15(51.7)	14(48.3)	3.082[1.003-9.472]	0.049	2.999[0.974-9.237]	0.056
Class V: Flammable	9(64.3)	5(35.7)	3.963[0.481-32.664]	0.201	4.572[0.550-37.986]	0.159
Training on PPEs						
No	164(79.6)	42(20.4)	1	1	1	1
Yes	106(58.6)	75(41.4)	1.187[0.646-2.179]	0.581	1.485[0.726-3.038]	0.279
SOPs in Place						
No	70(97.2)	2(2.8)	1	1	1	1
Yes	200(63.5)	115(36.5)	27.200 [5.288 - 139.915]	0.000	25.773 [5.001 - 132.798]	0.000**

### 3.3 Level of Compliance to Safe Measures in the Use of Pesticides

On the general level of compliance to safe measures in the use of pesticide by farmers it was established only 30.2% were complying and the majority were not. These results are agreement with earlier study done in Uganda by Nalwanga *et al.*, [45]. Other studies also undertaken in Vietnam and China [46,32] also revealed that many farmers rate safety measures application relatively low and may even fail to dispose left over pesticide properly.

#### Association Between Personal and Institutional Determinants of Compliance to Safe Measures in the Use of Pesticides

To show this association, both chi square and bivariate logistic regression analyses were conducted at 95% level of significance.

The chi square analysis results on personal determinants are shown in Table 4 below while the institutional determinants are in Table 5.

### 3.4 Personal Determinants

The results in Table 4 show that four personal determinants, that is, education level ( $p = 0.000$ ), knowledge level ( $p = 0.012$ ), attitude ( $p = 0.000$ ) and risk perception ( $p = 0.000$ ) had significant association with compliance to safe measures in the use of pesticides among farmers in the study ( $p < 0.05$ ). Other individual factors including age group, marital status and peer influence were not significantly associated with compliance to safe measures in the use of pesticides among farmers in the study ( $p > 0.05$ ).

### 3.5 Institutional Determinants

Among the 4 institutional determinants only one was not significant (Table 5).

The three institutional determinants which were established to be significantly associated with compliance to safe measures were pesticide toxicity ( $p = 0.023$ ), training on PPEs ( $p = 0.000$ ), and standard operating procedures in place ( $p = 0.000$ ) at  $p < 0.05$ .

One institutional determinant, received inspection in the past year, was not significantly associated with compliance to safe measures in the use of pesticides among farmers in the study ( $p > 0.05$ ).

The multivariate logistic regression analysis of both the institutional and individual determinants

associated with compliance to safe measures in the use of pesticides among farmers was done and the results are given in Table 6.

The results (Table 6) show that only three determinants were significantly associated with compliance to safe use of pesticides. These are: Positive Attitude, High Risk Perception and Adhering to SOPs.

The results show that there was a strong statistically significant association between farmer's attitude and compliance to safe measures in the use of pesticides among farmers. The crude odds ratio [COR = 6.057, (CI 95% = 3.201 - 11.462)], implied that the odds of complying to safe measures of pesticide use among farmers who had positive attitude were about 6 times higher compared to those farmers who had negative attitudes towards safety measures of pesticide use. Whereas on carrying out multivariate analysis, adjusted odds ratio [AOR = 5.247, (CI 95% = 2.663 - 10.340,  $p = 0.000$ )] implied that the odds of complying to safe measures of pesticide use among farmers who had positive attitude towards safety measures were about 5 times higher compared to those farmers who had negative attitudes. This suggests that having a positive attitude towards safe use of pesticides increases the likelihoods of complying to safe measures of pesticides use. Therefore, the farmers' attitudes need to be improved as this would motivate them to comply to safe measures of pesticides use.

The above results are in agreement with previous studies in several countries including Nigeria and China [18,23,27] who also reported that having a positive attitude is significant in improving compliance to safe use of pesticides.

The results (Table 6) also show that risk perception had a strong statistically significant association with compliance to safe measures in the use of pesticides among farmers. The crude odds ratio [COR = 31.271, (CI 95% = 3.593 - 272.149)], implied that the odds of complying to safe measures of pesticide use among farmers who had a high-risk perception of pesticide use were about 31 times higher compared to those farmers who had a low-risk perception of pesticide use. Whereas on carrying out multivariate analysis, adjusted odds ratio [AOR = 31.507, (CI 95% = 3.551 - 279.565,  $p = 0.002$ )] implied that the odds of complying to safe measures of pesticide use among farmers who had a high-risk perception of pesticide use were

about 32 times higher compared to those farmers with low-risk perception.

The above results are similar to earlier findings in Greece, China and Malaysia [9,3,29] which reported that farmers with higher risk perception were more concerned about their health and hence paid more attention to compliance to safety measures when using pesticides.

The results (Table 6) finally also show that the presence of SOPs had a strong statistically significant association with compliance to safe measures in the use of pesticides among farmers. The crude odds ratio [COR = 27.200, (CI 95% = 5.288 - 139.915)], implied that the odds of complying to safe measures of pesticide use among farmers who reported having standard operating procedures (SOPs) in place were about 27 times higher compared to those farmers who reported not having the SOPs. Whereas on carrying out multivariate analysis, adjusted odds ratio [AOR = 25.773, (CI 95% = 5.001 - 132.798,  $p = 0.000$ )] implied that the odds of complying to safe measures of pesticide use among farmers who reported having SOPs in place were about 26 times higher compared to those farmers who reported not having the SOPs. This indicates that having SOPs in place increases the likelihood of the individual to comply to safe measures of pesticides use. Therefore, there is need to have SOPs available as this would enable more farmers to comply with the safety measures while using pesticides.

Ndayambaje et. al. [26], Strong et.al. [47] and Abdollahzadeh & Sharif [44] who carried out related studies in Rwanda, the US and Saudi Arabia respectively reported that presence of standard operating procedures had a significant association with the compliance to safe measures of pesticide use among the farmers and farm workers in the communities.

#### 4. CONCLUSION AND RECOMMENDATION

In conclusion the level of compliance to safe measures in the use of pesticides among farmers was low. Most of the farmers were older than 40 years and had primary school level of education were married but had high appreciation of risk in using pesticides. Among the personal determinants, attitude and risk perception were significant factors influencing compliance to safe measures in the use of pesticides among farmers. While among the institutional determinants, standard operational procedures in

place were also significantly associated with compliance to safe measures in the use of pesticides among farmers.

Therefore, there is need to work on improving farmers' attitudes, sensitizing them about the risks attached to use of pesticides, and provision of SOPs for pesticide use on their farms. Once the above are emphasised there is bound to be a positive change in compliance to safety measures while using pesticides.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. FAO. Pesticides use, pesticides trade and pesticides indicators. Global, Regional and Country trends, 1990–2020. FAOSTAT Analytical Brief 46; 2022. Available:<https://www.fao.org/3/cc0918en/c0918en.pdf>
2. Alavanja MC. Introduction: pesticides use and exposure extensive worldwide. Reviews on environmental health. 2009; 24(4):303–309. DOI:<https://doi.org/10.1515/reveh.2009.24.4.303>
3. UNEP. Environmental and Health Impacts of Pesticides and Fertilizers and Ways of Minimizing Them: Envisioning A Chemical-Safe World; 2022. Available:[https://wedocs.unep.org/bitstream/handle/20.500.11822/40351/Pesticides\\_Ch2.pdf](https://wedocs.unep.org/bitstream/handle/20.500.11822/40351/Pesticides_Ch2.pdf)
4. Directorate-General for external policies - policy department, European Parliament. The use of pesticides in developing countries and their impact on health and the right to food; 2021. Available:<https://www.europarl.europa.eu/cmsdata/219887/Pesticides%20health%20and%20food.pdf>
5. Miller GT, Spoolman S. Living in the Environment: Principles, Connections, and

**Commented [MOU5]:** This conclusion is too short and does not describe the objectives of the research as stated in the introduction. There are 3 objectives in the introduction and have not been answered in the conclusion of this study.  
(· identify the different factors related to compliance to safe measures in the use of pesticides among farmers in the sub- county;  
· establish the level of compliance to safety measures in the use of pesticides among farmers in the sub-county;  
· determine the association between the different factors and compliance to safe measures in the use of pesticides among farmers.)

- Solutions. Published by Cengage Learning; 2011.  
Available:<https://books.google.co.uk/books?id=QcQ8AAAAQBAJ>
6. Jallow MFA, Awadh DG, Albaho MS, Devi VY, Thomas BM. Pesticide Knowledge and Safety Practices among Farm Workers in Kuwait: Results of a Survey; 2017.  
DOI:<https://doi.org/10.3390/ijerph14040340>
  7. Kiene HT, Krungkraipetch N, Chantawong C. Factors Influencing Safety Pesticide Use Behavior among Farmers in Thai Nguyen, Vietnam. 52 Journal of Nursing and Health Sciences. 2016;10(3). September- December 2016.  
Available:<file:///C:/Users/DRM/Downloads/KI%C3%8AN-Factors%20Influencing%20Safety%20Pesticide%20Use%20Behavior%20among%20Farmers%20in%20Thai%20Nguyen,%20Vietnam-1.pdf>
  8. Khanal G, Singh A. Patterns of Pesticide Use and Associated Factors Among the Commercial Farmers of Chitwan, Nepal. 2016;10:1–7.  
DOI:<https://doi.org/10.4137/EHI.S40973>
  9. Damalas CA, Hashemi SM. Pesticide risk perception and use of personal protective equipment among young and old cotton growers in northern Greece. *Agrociencia. Texcoco abr./may.* 2010. 2010;44(3)  
Available:[https://www.scielo.org.mx/scielo.php?script=sci\\_arttext&pid=S1405-31952010000300010](https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1405-31952010000300010)
  10. Tudi M, Daniel Ruan H, Wang L, Lyu J, Sadler R, Connell D, Chu C, Phung DT. Agriculture Development, Pesticide Application and Its Impact on the Environment. *International journal of environmental research and public health*, 2021;18(3):1112.  
DOI:<https://doi.org/10.3390/ijerph18031112>
  11. Kwame Osei Boateng, Enock Dankyi, Isaac Kingsley Amponsah, Godfred Kweku Awudzi, Emmanuel Amponsah, Godfred Darko. Knowledge, perception, and pesticide application practices among smallholder cocoa farmers in four Ghanaian cocoa-growing regions, *Toxicology Reports*. 2023;10:46-55, ISSN 2214-7500.  
DOI:<https://doi.org/10.1016/j.toxrep.2022.12.008>
  12. Afari-Sefa V, Asare-Bediako E, Kenyon L, Micah JA. Pesticide Use Practices and Perceptions of Vegetable Farmers in the Cocoa Belts of the Ashanti and Western Regions of Ghana. *Adv Crop Sci Tech* 2015;3:174.  
DOI:10.4172/2329-8863.1000174
  13. Kwadzo M, Annor-Frempong F, Lambon JB. Pesticide use and health hazards among small-scale commercial vegetable growers in the Nsawam Adoagyiri Municipality in the Eastern Region of Ghana. *J Bio Agric Healthcare* 2015;5(18).  
Available:<https://www.iiste.org/Journals/index.php/JBAH/article/view/26012/26540>
  14. Cox Peter. Pesticide use in Tanzania. Overseas Development Institute. Published by the Overseas Development Institute and the Economic Research Bureau. Percy Street, London W1P 0JB. ISBN 0 85003 092 7. 1985;10-11.  
Available:<https://cdn.odi.org/media/documents/8147.pdf>
  15. Massomo SMS. Vegetable Pest Management and Pesticide use in Kigoma, Tanzania: Challenges and way Forward. *Hurija Journal. The Open University of Tanzania*; 2019;26(1).  
Available:<https://www.semanticscholar.org/paper/Vegetable-Pest-Management-and-Pesticide-use-in-and-Massomo/9ec6ec8263b2604f3c4825f540f1f83e46dd1d22>
  16. Areco-Rwanda Nziza. Highly Hazardous Pesticides (HHPs) Rwanda Situation Report. IPEN Toxics-Free SDGs Campaign. Kigali, Rwanda. March; 2020.  
Available:[https://ipen.org/sites/default/files/documents/final\\_rwanda\\_hhps\\_report\\_areco\\_10\\_july\\_2020.pdf](https://ipen.org/sites/default/files/documents/final_rwanda_hhps_report_areco_10_july_2020.pdf)
  17. Louise Wipfler and Mechteld ter Horst. Pesticide Management in Rwanda: Analysis of the current pest control products administration and management system. Wageningen Environmental Research. Wageningen; August 2018.  
Available:<https://edepot.wur.nl/457874>
  18. Afshari M, Karimi-Shahanjarini A, Khoshravesh S, & Besharati F. Effectiveness of interventions to promote pesticide safety and reduce pesticide exposure in agricultural health studies: A systematic review. *PloS one*. 2021;16(1): e0245766.  
DOI:<https://doi.org/10.1371/journal.pone.0245766>
  19. Damalas CA, Eleftherohorinos IG. Pesticide exposure, safety issues, and risk assessment indicators. *International journal of environmental research and public health*, 2011;8(5):1402–1419.

- DOI:<https://doi.org/10.3390/ijerph8051402>
20. WHO. The WHO Recommended Classification of Pesticides by Hazard and guidelines to classification; 2019. Available:<https://www.who.int/publications/i/item/9789240005662>
21. Sekimpi DK, Maziina J, Racheal A, Jørs E. Pesticide knowledge, practice and attitude and how it affects the health of small-scale farmers in Uganda: A cross-sectional study. *African Health Sciences*, 2021;14(2):420–433. DOI:<https://doi.org/10.4314/ahs.v14i2.19>
22. Oesterlund AH, Thomsen JF, Sekimpi DK, Maziina J, Racheal A, Jørs E. Pesticide knowledge, practice and attitude and how it affects the health of small-scale farmers in Uganda: a cross-sectional study. *African health sciences*, 2014;14(2):420–433. DOI:<https://doi.org/10.4314/ahs.v14i2.19>
23. Wang J, Chu M. Determinants of pesticide application: an empirical analysis with theory of planned behaviour; 2017. DOI:<https://doi.org/10.1108/CAER-02-2017-0030>
24. Despotović J, Rodić V, Bošnjak D, Milojević V. Understanding farmers' behaviour regarding pesticide use in Vojvodina region *Economics of Agriculture*, 2023;70(1):47–60. DOI:<https://doi.org/10.59267/ekoPolj230147D>
25. Thapa S, Thapa B, Bhandari R, Jamkatel D, Acharya P, Rawal S, Bista S, Singh R, Prasai A, Bharati S, Basnet A. Knowledge on Pesticide Handling Practices and Factors Affecting Adoption of Personal Protective Equipment: A Case of Farmers from Nepal. 2021. *Advances in Agriculture*. Volume 2021;2021 | Article ID 5569835. DOI:<https://doi.org/10.1155/2021/5569835>
26. Ndayambaje B, Amuguni H, Coffin-Schmitt J, Sibo N, Ntawubizi M, VanWormer E. Pesticide Application Practices and Knowledge among Small-Scale Local Rice Growers and Communities in Rwanda: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*. 2019;16(23):4770. DOI:<https://doi.org/10.3390/ijerph16234770>
27. Abegunrin OO, Adeoye AS, Babatunde RO, Ogunwale OG, Adegbite AM. *Isbn*: 2020;12(1):2141–1778.
28. Yalley J. Pesticides Use and Safety Compliance among Rural Maize Farmers; A Case of the Sunyani West District, Ghana. *International Journal of Research and Scientific Innovation (IJRSI) | Volume, Issue, October 2019;VI(X)*. ISSN 2321–2705. Available:<https://www.rsisinternational.org/journals/ijrsi/digital-library/volume-6-issue-10/34-61.pdf>
29. Khan S, Sulaiman BIN, Ibrahim Y, Jeffree MS. Evaluating the perception of farmers towards pesticides and the health effect of pesticides: A cross-sectional study in the oil palm plantations of Papar, Malaysia. 2019;12(1):15–25. DOI:<https://doi.org/10.2478/intox-2019-0003>
30. Bilalib T, Peng Z, Cao C, Luo M, Liu Y, Oppong N. Compliance with pesticides' use regulations and guidelines among vegetable farmers: Evidence from the field. *Cleaner Engineering and Technology*, 2022;6: 100399. DOI:<https://doi.org/10.1016/j.clet.2022.100399>
31. Lekei EE, Aiwerasia V, London L. Pesticide retailers' knowledge and handling practices in selected towns of Tanzania. *Environmental Health* 2014; 13:79. Available:<http://www.ehjournal.net/content/13/1/79>
32. Jianjun J, Wang W, He R, Gong H. Pesticide Use and Risk Perceptions among Small-Scale Farmers in Anqiu Pesticide Use and Risk Perceptions among Small-Scale Farmers in Anqiu County, China. December; 2016. DOI:<https://doi.org/10.3390/ijerph14010029>
33. Öztas D, Kurt B, Koç A, Akbaba M, İlter H. 1771 Knowledge level, attitude and behavior of farmers in the Çukurova region about the use of pesticides. 2018;A462:3-A462. DOI:<https://doi.org/10.1136/oemed-2018-icoabstracts.1315>
34. Miyittah MK, Kwadzo M, Gyamfua AP, Dodor DE. Health risk factors associated with pesticide use by watermelon farmers in Central region, Ghana. *Environmental Systems Research*; 2020. DOI:<https://doi.org/10.1186/s40068-020-00170-9>
35. PROBICOU. Pesticides use and agriculture in Uganda; 2013. Available:<https://www.probicou.org/publications/Magazine%20July%202013.pdf>

36. Semalulu O, Hecky RE, Muir D. Water Quality and Ecosystems Management Component 162. CHAPTER 10 in Agricultural chemicals and metal contaminants in the Ugandan catchment of Lake Victoria. Water Quality and Quantity Synthesis Final Report, LVEMP December; 2005.  
Available from: <https://www.mwe.go.ug/sites/default/files/library/Chapter%2010%20Pesticide%20use.pdf>
37. Carter, Sarah, Garfied, Sara, Newbould, Jenny, Rennie, Timothy & Taylor, David, Bury, Michael & Campling, Natasha. A Review of the use of the Health Belief Model (HBM), the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB) and the Trans-Theoretical Model (TTM) to study and predict health related behaviour change; 2006.  
Available: [https://www.researchgate.net/publication/334114235\\_A\\_Review\\_of\\_the\\_use\\_of\\_the\\_Health\\_Belief\\_Model\\_HBM\\_the\\_Theory\\_of\\_Reasoned\\_Action\\_TRA\\_the\\_Theory\\_of\\_Planned\\_Behaviour\\_TPB\\_and\\_the\\_Trans-Theoretical\\_Model\\_TTM\\_to\\_study\\_and\\_predict\\_health\\_related\\_behavior](https://www.researchgate.net/publication/334114235_A_Review_of_the_use_of_the_Health_Belief_Model_HBM_the_Theory_of_Reasoned_Action_TRA_the_Theory_of_Planned_Behaviour_TPB_and_the_Trans-Theoretical_Model_TTM_to_study_and_predict_health_related_behavior)
38. Levin KA. Study design III: Cross-sectional studies. Evidence-Based Dentistry, 2006; 7(1):24–25.  
DOI: <https://doi.org/10.1038/sj.ebd.6400375>
39. Setia MS. Methodology series module 3: Cross-sectional studies. Indian Journal of Dermatology, 2016;61(3):261–264.  
DOI: <https://doi.org/10.4103/0019-5154.182410>
40. Apuke OD. Quantitative Research Methods : A Synopsis Approach. Kuwait Chapter of Arabian Journal of Business and Management Review, 2017;6(11):40–47.  
DOI: <https://doi.org/10.12816/0040336>
41. Masindi District Local Government. Local Government Performance Assessment Results 2019\_2020. Social Economic Statistics; 2020.  
Available: <https://www.masindi.go.ug/district/population>
42. Kothari CR. Research Methodology: Methods and techniques. 2nd Revised Edition. New Age International Publishers. New Delhi. 2004;(13):978-81-224-2488-1.  
DOI: <https://doi.org/10.5771/9783956506376-57>
43. Tago D, Andersson H, Treich N. Pesticides and health: a review of evidence on health effects, valuation of risks, and benefit-cost analysis. Advances in health economics and health services research. 2014;24: 203–295.  
Available: <https://pubmed.ncbi.nlm.nih.gov/25244910/>
44. Abdollahzadeh G, Sharif M. Journal of the Saudi Society of Agricultural Sciences Predicting farmers ' intention to use PPE for prevent pesticide adverse effects: An examination of the Health Belief Model (HBM). Journal of the Saudi Society of Agricultural Sciences. 2021;20(1):40–47.  
DOI: <https://doi.org/10.1016/j.jssas.2020.11.001>
45. Nalwanga E, Ssempebwa JC. Knowledge and practices of in-home pesticide use: A community survey in uganda. Journal of Environmental and Public Health; 2011.  
DOI: <https://doi.org/10.1155/2011/230894>
46. Hoi PV, Mol APJ, Oosterveer P, van den Brink PJ, Huong PTM. Pesticide use in Vietnamese vegetable production: a 10-year study. International Journal of Agricultural Sustainability, 2016;325-338. [3].  
DOI: 10.1080/14735903.2015.1134395.  
Available: <https://doi.org/10.1080/14735903.2015.1134395>
47. Strong LL, Thompson AB, Koepsell TD, Meischke H. Factors Associated With Pesticide Safety Practices in Farmworkers. 81(July 2007), 2008;69–81.  
DOI: <https://doi.org/10.1002/ajim.20519>