Analyzing Factors Affecting Farmers' Safe Pesticide Handling Practices in Southwest of Ethiopia: Implications for Policy

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ABSTRACT

BACKGROUND: Pesticides play a crucial role in enhancing agricultural productivity by controlling pests. However, inadequate pesticide handling practices have a considerable adverse impact on human health. Nevertheless, there is limited knowledge regarding the extent of safe pesticide handling practices, particularly in low-income settings like Ethiopia. Hence, this study seeks to evaluate the implementation of safe pesticide handling practices and identify the factors associated with the status of the handling practices in low-income settings in Ethiopia.

METHODS: A cross-sectional study was undertaken, involving 468 farmers randomly selected for participation. Data collection was carried out through structured questionnaires and face-to-face interviews. The analysis aimed to assess the proportion of safe pesticide handling practices (SPHP) and investigate the factors associated with SPHP was done using binary logistic regression. Explanatory variables with a *P*-value <0.25 were included in the final analysis. The factors were determined based on adjusted odds ratios and 95% confidence intervals, *P*-value <.05. Model fit was evaluated using the Hosmer and Lemeshow tests.

RESULTS: From the findings of our study, only 45.7% of farmers practiced SPHP, with factors such as education, experience, pesticide usage, and attitude toward safe practices influencing their practices. Farmers with education status primary and above were two times more likely to practice good handling of pesticides than those who didn't attend formal education. Farmers with a maximum of 5 years of experience in vegetable farming were 2.4 times more likely to exhibit good handling practices compared to their counterparts. Furthermore, farmers with favorable attitudes toward pesticide handling were 4.2 times more likely to engage in good pesticide handling practices than those with unfavorable attitudes. Therefore, the agricultural sectors, health sectors, and farmer associations should focus on these factors in order to mitigate the health risks associated with poor pesticide handling.

KEYWORDS: Ethiopia, vegetable, farmers, safe, handling, pesticide, factors

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Introduction

Pesticides are chemicals used to control, prevent, or destroy pests, including vectors, unwanted plant or animal species, diseases, or harm during food production, processing, storage, or marketing.[1] Despite their benefits in improving agricultural products, they may also cause health risks to the sprayers, product users, and the ecosystem.[2-4] Over 1000 pesticides are used globally to prevent food damage or destruction, each with unique properties and toxicological effects.[5]

The emerging health risks of the use of toxic compounds call for the need for safe handling practices, which are underestimated by pesticide handlers. Therefore, safe handling practices are crucial to reducing health risks and preventing exposure.[6] Safe pesticide handling involves the practice of wearing personal protective equipment, storing pesticides separately, following the application guidelines, and disposing of empty containers properly during pesticide handling to ensure safety and prevent contamination.[7,8] Evidence from the literature revealed that poor handling practices and unregulated use of pesticides in agriculture pose significant risks to human health, particularly in Africa.[9-12] Occupational exposure is common, with farm workers being a primary risk group.[12] This is because farmers can accidentally expose themselves to pesticides through various activities, including mixing, loading, spraying, direct contact with vegetation, cleaning equipment, and vapor drift.[13] The adverse effects of pesticides are increasing in developing countries[14] partly attributed to low education levels and unfavorable working conditions.

In Ethiopia, poor handling practices, a lack of knowledge about SPH (Safe pesticide handling), and unintentional application errors can pose serious health risks to farmers.[7,9,15,16] Farmers' knowledge and attitude toward potential pesticide hazards are essential in preventing exposure.[17] However, the information related to the prevalence of SPHP and the factors

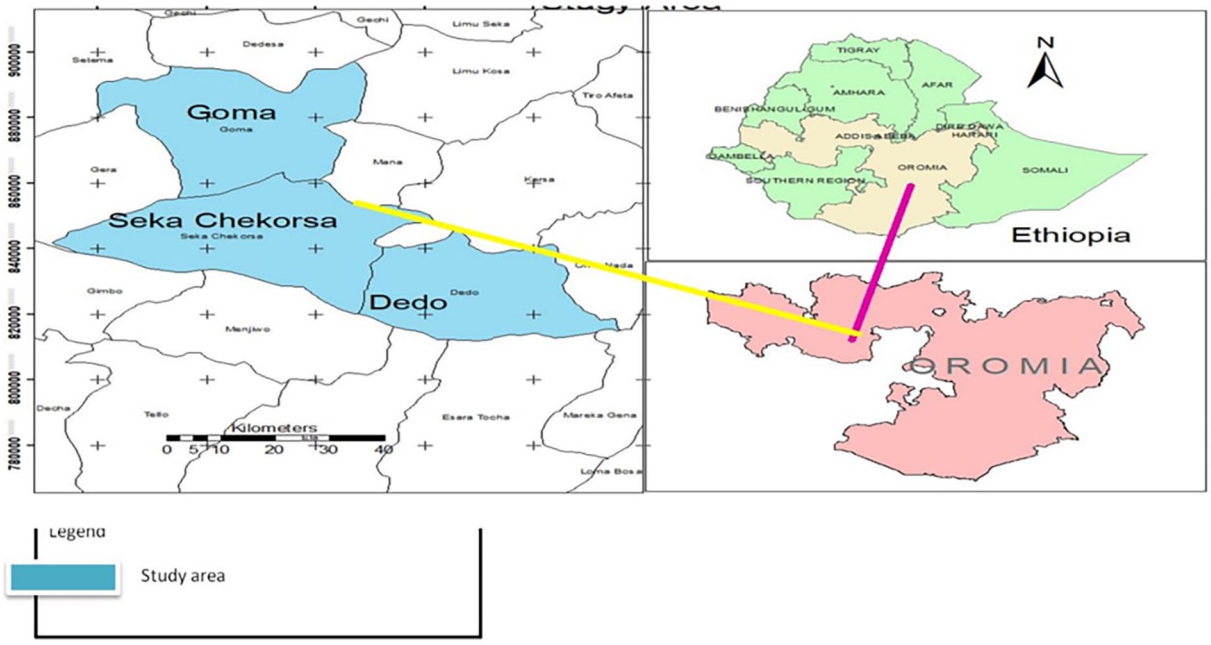

Figure 1. Study area map of Jimma Zone, Oromia Region, Ethiopia.

determining the safe handling practice is limited in Ethiopia. Therefore, this study investigates the level of safe pesticide handling practices and factors associated with SPHP among farmers participating in vegetable farming in selected districts in Jimma Zone, South West Ethiopia. The findings of this study may help farmers and rural development agents in mitigating the risks related to pesticide handling. More importantly, it helps the local agriculture sector, health sector, and policymakers to identify the interventions targeted to improve safe handling practices.

Methods and Materials

Study area

The study was conducted in the Jimma zone of the Oromia region in southwestern Ethiopia, focusing on three districts: Gomma, Dedo, and Seka Chokorsa (Figure 1). Jimma zone, which comprises 20 administrative districts with a population of 3.4 million, has a total area of 15 569 km^2 and an annual rainfall range of 1200 to 2800 mm. Subsistence farming is the primary source of income for 85% of the inhabitants.[18] The area has suitable agro ecological potential and has the lowest drought risk rating in the country.[19] Smallholder farmers grow cash crops such as coffee, tea, fruits, and vegetables to enhance family income and achieve food security.[20] The study focuses on farmers who participated in vegetable farming (such as onions, tomatoes, potatoes, and garlic). Vegetables are the most chosen crops due to their high productivity and quick production cycle, resulting in a larger return per unit area and significantly reducing unemployment.[21]

Study design and period

A cross-sectional study was conducted among 468 household vegetable farmers in Jimma zone districts, Seka Chokersa, Dedo, and Goma, using a structured questionnaire. The survey was conducted from September to December 2023, with informed consent from household heads.

Sample size determination

The sample size was determined using a single population proportion formula.[22] with the following assumptions: P = was the proportion of good SPHP from north Ethiopia, Fogera district (24.4%),[7] and Z α /2 = refers to the cut of the value of the normal distribution and is based on a 95% confidence interval.

$$n = \frac{\left(Z\frac{\alpha}{2}\right)^2 \left(P^*\left(1-P\right)\right)}{d^2} = \frac{\left(1.96\right)^2 \left(0.244^*\left(1-0.244\right)\right)}{\left(0.05\right)^2} = 283.5$$

Considering the design effect of 1.5, since the selection stages, and 10% non-response rate, the final sample size was **468 farmers**.

Operational definitions

- **Pesticide use:** Pesticides are substances or mixtures used in agriculture or public health programs to protect plants from pests, weeds, and diseases.[17]
- **Safe pesticide handling** involves the practice of wearing personal protective equipment, storing pesticides separately, following the application guidelines, and disposing

of empty containers properly during pesticide handling to ensure safety and prevent contamination.[7,8]

Sampling techniques

Data collection took place in three districts within the Jimma Zone: Dedo, Gomma, and Seka Chokorsa. The study participants were selected through a three-stage process. In the first stage, three districts were purposefully chosen from a total of 20 districts in the Jimma Zone, based on their high levels of participation in vegetable farming. In the second stage, three kebeles (small administrative units) were randomly selected from each district. In the third stage, households were proportionally selected from each kebele. Specifically, kebeles selected were Ofkole Waro and Afalti from Dedo, Dabo, Ushan, and Gabo from Seka Chokorsa, and Ganji, Jimate, and Chemi from Gomma. The study employed a lottery method to identify the kebeles, and households were selected using systematic random sampling. The head of the household served as the respondent, and if the head was unable to participate in farming activities due to old age or illness, an adult individual (age 18 or above) engaged in farming activities was selected as the respondent.

Data collection

The data were collected using face-to-face interviews using a pretested, structured questionnaire. The questionnaire was written in English and translated into the Afan Oromo language by experts. It was back-translated to check its constancy in translation. The questionnaire contains socio-demographic information, pesticide utilization variables, knowledge, and attitudes of the farmers about safe pesticide handling and safe pesticide handling practices. Nine trained agricultural extension workers collected the data, and two environmental health experts participated in supervising the fieldwork.

Data quality assurance

Data quality was assured through provision of training for data collectors and supervisors on the tool, using standardized tools (pre-tested), and closes supervision during fieldwork. Two days of training were given to data collectors and supervisors. The data collection procedure was supervised carefully to increase the accuracy and completeness of the data every day during the fieldwork.

Data processing and analysis

The data were entered into Epidata version 3.1[23] and exported to SPSS version 20[24] for analysis. Descriptive analysis: mean and standard deviation were used for age, average monthly family income, and duration of participation in farming activities. For the categorical variables, sex, marital status, educational status, safe pesticide handling practice, attitudes toward safe handling practice, age category, and knowledge about safe pesticide handling practice were analyzed using frequency and percentage.

Safe pesticide handling practice was measured using 10 questions (items) with Likert scale of 5 levels. The safe handling practices were computed from the responses to the 10 questions using the mean as a cut point; values equal to or above the mean were considered "*good practices*," and values below the mean were considered "*poor practices*."[25] Attitudes toward safe handling practices were measured using 9 questions with Likert scale of 5 levels. The attitudes of the respondents toward safe practice were computed from the responses to 9 questions using the mean as a cut point, and the values equal to or above the mean were "*positive attitudes*," and the values below the mean were "*negative attitudes*." The knowledge of farmers about safe handling practices was measured using 8 questions with Likert scale of 5 levels. The knowledge of the respondents on the safe handling of pesticides was computed from 8 questions, considering the mean as the cut point, and the value equal to the mean or above the mean was considered "*good knowledge*," and the value below the mean was "*poor knowledge*."

Logistic regression analysis was performed to identify factors associated with safe handling practices (i.e., the outcome variable). All explanatory variables associated with the safe pesticide handling practice in the bivariate analysis with a *P*-value <0.25 were included in the final analysis. The adjusted odds ratio (AOR) and the 95% confidence interval [95% CI] were used to determine the effect of potentially associated variables on the outcome variable by controlling confounders. All variables with a *P*-value of $<.05$ were considered to have statistically significant associations with the outcome variable. The Hosmer and Lemeshow tests were used to check the model's goodness of fit.

Ethical consideration

The study's ethical protocol was approved by Jimma University's Institutional Research Ethical Review Board (IRB). Written informed consent was obtained from the study participants before data collection; all the records were noted in full anonymity, not including personal identifiers, and secured in all processes of the data handling and analysis.

Results

Socio-demographic characteristics

The study involved 468 farmers, with 92.2% being male with a mean age of 43 years. Over half attended primary or higher education, and most were married (90.8%). Approximately 54.3% of the participants had family members totaling five or more individuals. Around 47% of the participants possessed one or more hectares of farmland. The majority of participants (94.4%) had engaged in farming for duration of 5 years or

Table 1. Socio-demographic characteristics of study participants in selected districts in Jimma Zone, Southwest Ethiopia, 2023.

VARIABLES	CATEGORIES	FREQUENCY	PERCENT
Sex	Male	422	90.2
	Female	46	9.8
Age category (mean = 43.1, SD:8.9)	18-30	47	10
	31-40	155	33.1
	41-50	179	38.2
	50 or above	87	18.6
Marital status	Single	24	5.1
	Married	425	90.8
	Widowed	11	2.4
	Separated	8	1.7
Educational status	No formal education	128	27.4
	Primary and above	340	72.6
Farmland status	Landowner	27	5.8
	Tenant	441	94.2
Family size (mean = 5.16, SD = 1.8)	Less than 5	214	45.7
	5 or above	254	54.3
Average monthly income (mean = 2010 Birr)	Less than 5000 Birr	448	95.7
	5000 Birr or above	20	4.3
Land size in hectare (mean = 1.6 SD:2.4)	Less than one	248	53
	One hand above	220	47
Duration since participating in farming	Less than 5 years	26	5.6
	5 years and above	447	94.4
Duration since participating in vegetable farming	Less than 5 years	257	54.9
	5 years and above	211	45.1

Source: Survey.

more, with 45.1% specifically involved in vegetable farming (Table 1).

Pesticide utilization patterns among farmers. The study analyzed pesticide utilization patterns among farmers who participated in vegetable farming in the Jimma Zone, and all of them have previous utilization histories. The majority (98.1%) used at least one type of pesticide during the current season, with frequency varying from once to more than twice. Most (56.6%) used pesticides only for vegetables, while 42.5% used vegetables and cereals. Trends in pesticide use were increasing (85.3%), with only 3.2% decreasing in the last 5 years. Information on pesticide use came from rural development agents, other farmers, and pesticide retailers. Most (78.6%) respondents got pesticides from licensed dealers, and 65% knew the pesticide names they used before (Table 2).

Safety and health risks during pesticide spraying

The study revealed that 84.8% of respondents used at least one type of personal protective device during previous pesticide sprays, while 75% experienced at least one acute symptom, such as vomiting, headache, diarrhea, difficulty breathing, or sleeplessness, from the health risk self-reports of 351 participants (Table 3).

Safe pesticide handling practices (SPHP) among farmers

To assess safe pesticide handling practices, the study employed a scale consisting of 5 items. The mean value was utilized as the threshold for categorizing the responses. The findings revealed that 28.8% of the respondents consistently used personal protective equipment (PPE), 42.5% stored pesticides

Table 2. Pesticide utilization patterns among vegetable farmers in selected districts in Jimma Zone, 2023.

VARIABLES	CATEGORIES	FREQUENCY	PERCENT
Using pesticides in the current farming season	Yes	459	98.1
	No	9	1.9
Frequency utilization year-round	Once	153	32.7
	Twice	153	32.7
	More than two times	162	34.6
Type of crops they used for	Only for vegetables	265	56.6
	Vegetables and cereals	199	42.5
	Vegetables and coffee	4	0.9
Trends in pesticide use	Increasing	399	85.3
	Constant	54	11.5
	Decreasing	15	3.2
Information about pesticide use	Other farmers	58	12.4
	Rural development agents	367	78.4
	Pesticides retailers	43	9.2
Source of pesticides	From licensed dealers	368	78.6
	Government	47	10
	Informal trades in local markets	36	7.7
	From farmers union	17	3.6
Know the type and name of pesticides they used	Yes	304	65
	No	164	35
Encounter unlabeled pesticides during buying	Yes	25	5.3
	No	443	94.7
Experience in using pesticides	Less than 2 years	69	14.7
	2 years and above	399	85.3

Source: Survey.

securely, 23.7% followed application instructions, 41% sought expert advice, and merely 16% disposed of pesticide containers and leftovers according to recommendations. Overall, 45.7% of the respondents demonstrated good pesticide handling practices, whereas 54.3% exhibited poor practices (Table 4).

Attitude of farmers toward safe pesticide handling practices

The study assessed respondents' attitudes toward safe pesticide handling practices using a scale of 5 with nine questions. The mean value was used as a cut point, with a value above the mean indicating a favorable attitude. Out of 468 respondents, 45.1% had a favorable attitude toward safe pesticide handling practices, while 54.9% had an unfavorable attitude (Table 5).

Knowledge of farmers about safe pesticide handling practices

A study assessed the knowledge of 468 respondents about safe pesticide handling practices using multiple questions with a scale of 5. The mean value was used as a cut point, with a value above the mean indicating good knowledge and below the mean indicating poor knowledge. Out of 468 respondents, 44% had good knowledge, while 56% had poor knowledge (Table 6).

Factors associated with SPHP among farmers

In this study, safe pesticide handling practices were examined as the outcome variable, and various factors were assessed for their potential association. Initially, a crude analysis was

Table 3. Safety and acute health risks experienced by pesticide spraying among selected vegetable farmers in Jimma Zone, 2023.

VARIABLES	CATEGORIES	FREQUENCY	PERCENT
Use personal protective equipment (PPE) (i.e., at least one)	Yes	397	84.8
	No	71	15.2
Use gloves	Always	25	5.3
	Sometimes	103	22
	Never	340	72.6
Use face mask	Always	94	20.1
	Sometimes	117	25
	Never	257	54.9
Use eye glasses	Always	16	3.4
	Sometimes	57	12.2
	Never	395	84.4
Use boots/shoes	Always	261	55.8
	Sometimes	115	24.6
	Never	92	19.7
Use long trousers	Always	64	13.7
	Sometimes	145	31
	Never	259	55.3
Acute health symptoms (i.e., at least one)	Yes	351	75
	No	117	25
Vomiting	Always	5	1.1
	Sometimes	183	39.1
	Never	280	59.8
Headache	Always	20	4.3
	Sometimes	158	33.8
	Never	290	62.0
Diarrhea	Always	3	0.6
	Sometimes	7	1.5
	Never	458	97.9
Difficulty of breathing	Always	6	1.3
	Sometimes	69	14.7
	Never	393	84
Sleeplessness	Always	2	0.4
	Sometimes	88	18.8
	Never	378	80.8

Source: Survey.

Table 4. Safe pesticide handling practices among vegetable farmers in the selected districts of Jimma Zone, 2023.

SAFE PRACTICES	LEVEL OF PRACTICE	FREQUENCY	PERCENT	MEAN	STANDARD DEVIATION
Use PPE during spraying.	Always	135	28.8	2.18	0.95
	Often	159	34.0		
	Sometimes	103	22.0		
	Never	71	15.2		
Store pesticides in separate & and secured places.	Always	199	42.5	1.75	0.76
	Often	198	42.3		
	Sometimes	64	13.7		
	Rarely	5	1.1		
	Never	2	0.4		
Flow instructions and apply the recommended dose.	Always	111	23.7	2.15	0.85
	Often	203	43.4		
	Sometimes	126	26.9		
	Rarely	26	5.6		
	Never	2	0.4		
Seeks advice from experts during pesticide application.	Always	192	41.0	1.86	0.85
	Often	165	35.3		
	Sometimes	97	20.7		
	Rarely	14	3.0		
Dispose of pesticide containers and leftovers as recommended.	Always	75	16.0	2.43	0.95
	Often	184	39.3		
	Sometimes	149	31.8		
	Rarely	52	11.1		
	Never	8	1.7		
Regularly inspect and maintain pesticide application equipment.	Always	130	27.8	2.25	0.95
	Often	136	29.1		
	Sometimes	168	35.9		
	Rarely	32	6.8		
	Never	2	0.4		
Record and maintain the information about pesticide use.	Always	89	19.0	2.56	1.15
	Often	162	34.6		
	Sometimes	109	23.3		
	Rarely	81	17.3		
	Never	27	5.8		
Avoid pesticide application during unfavorable weather.	Always	77	16.5	2.77	1.22
	Often	148	31.6		
	Sometimes	83	17.7		
	Rarely	125	26.7		
	Strongly rarely	35	7.5		

(Continued)

Table 4. (Continued)

SAFE PRACTICES	LEVEL OF PRACTICE	FREQUENCY	PERCENT	MEAN	STANDARD DEVIATION
Participated in training programs or workshops to improve pesticide handling practices and decrease contamination	Always	123	26.3	2.46	1.22
	Often	144	30.8		
	Sometimes	96	20.5		
	Rarely	74	15.8		
	Never	31	6.6		
Overall all pesticide-handling practice	Poor	254	54.3	2.32	0.76
	Good	214	45.7		

Source: Survey.

Table 5. Attitude of farmers toward safe pesticide handling practice among vegetable farmers in selected districts in Jimma Zone, 2023.

STATEMENTS	LEVEL OF AGREEMENT	FREQUENCY	PERCENT	MEAN	*STANDARD DEVIATION*
Believe proper use of pesticides is necessary for successful agricultural production	Strongly agree	296	63.3	1.46	*0.665*
	Agree	131	28.0		
	Neutral	39	8.3		
	Disagree	2	0.4		
Believe improper pesticide use has potential negative effects on human health	Strongly agree	262	56.0	1.55	*0.714*
	Agree	163	34.8		
	Neutral	34	7.3		
	Disagree	9	1.9		
Believe training help to adopt safer pesticide use practices	Strongly agree	128	27.4	2.02	*0.828*
	Agree	232	49.6		
	Neutral	80	17.1		
	Disagree	28	6.0		
Believe improper handling of pesticides have environmental impacts	Strongly agree	147	31.4	1.91	*0.793*
	Agree	233	49.8		
	Neutral	74	15.8		
	Disagree	10	2.1		
	Strongly disagree	4	0.9		
Believe regulations should be enforced to control pesticide use	Strongly agree	104	22.2	1.97	*0.704*
	Agree	290	62.0		
	Neutral	56	12.0		
	Disagree	18	3.8		
Believe advice and recommendations of agricultural extension workers regarding pesticide use handling are important	Strongly agree	278	59.4	1.50	*0.691*
	Agree	145	31.0		
	Neutral	41	8.8		
	Disagree	4	0.9		

(Continued)

Table 5. (Continued)

STATEMENTS	LEVEL OF AGREEMENT	FREQUENCY	PERCENT	MEAN	*STANDARD DEVIATION*
Believe failure to read and understand the instructions on pesticide containers can lead to adverse effects on human health	Strongly agree	182	38.9	1.79	*0.757*
	Agree	212	45.3		
	Neutral	65	13.9		
	Disagree	8	1.7		
	Strongly disagree	1	0.2		
Believe proper handling practice of pesticides is important to avoid pesticide residues in crops, vegetables	Strongly agree	90	19.2	2.03	*0.698*
	Agree	290	62.0		
	Neutral	73	15.6		
	Disagree	14	3.0		
	Strongly disagree	1	0.2		
Believe training and adopting new techniques and proper pesticide handling practices would promote safer pesticide use	Strongly agree	98	20.94	2.00	*0.708*
	Agree	288	61.54		
	Neutral	69	14.74		
	Disagree	10	2.14		
	Strongly disagree	3	Overall		
Overall attitudes toward pesticide handling practice	Unfavorable	257	54.9		
	Favorable	**211**	**45.1**		

Source: Survey.

Table 6. Knowledge of farmers about safe pesticide handling practices among vegetable farmers in selected districts in Jimma Zone, 2023.

STATEMENTS	LEVEL OF AGREEMENT	FREQUENCY	PERCENT	MEAN	STANDARD DEVIATION
Improper use of pesticides causes potential health risks	Strongly agree	236	50.4	1.55	0.617
	Agree	210	44.9		
	Neutral	19	4.1		
	Disagree	2	0.4		
	Strongly disagree	1	0.2		
Proper understanding of pesticide application methods decreases health risks	Strongly agree	231	49.4	1.63	0.718
	Agree	182	38.9		
	Neutral	51	10.9		
	Disagree	3	0.6		
	Strongly disagree	1	0.2		
During handling pesticides, the use of personal protective equipment (PPE) is important	Strongly agree	187	40.0	1.82	0.803
	Agree	190	40.6		
	Neutral	78	16.7		
	Disagree	13	2.8		

(Continued)

Table 6. (Continued)

STATEMENTS	LEVEL OF AGREEMENT	FREQUENCY	PERCENT	MEAN	STANDARD DEVIATION
Know that familiarity with the regulations and guidelines for pesticide use decreases environmental risks	Strongly agree	146	31.2	1.91	0.767
	Agree	232	49.6		
	Neutral	79	16.9		
	Disagree	9	1.9		
		2	0.4		
Knowledge about the potential environmental impacts of pesticide use is paramount	Strongly agree	122	26.1	1.99	L0.765
	Agree	244	52.1		
	Neutral	89	19.0		
	Disagree	11	2.4		
	Strongly disagree	2	0.4		
Know information to identify the different types of pesticides and their specific uses is important for proper handling of pesticides	Strongly agree	168	35.9	1.82	0.737
	Agree	224	47.9		
	Neutral	71	15.2		
	Disagree	3	0.6		
	Strongly disagree	2	0.4		
Know that reading and interpreting pesticide labels and instructions decreases the risk of exposure	Strongly agree	178	38.0	1.87	0.850
	Agree	197	42.1		
	Neutral	70	15.0		
	Disagree	22	4.7		
	Strongly disagree	1	0.2		
Know that the proper storage and disposal of pesticides decreases peril	Strongly agree	114	24.4	1.93	0.678
	Agree	283	60.5		
	Neutral	62	13.2		
	Disagree	8	1.7		
	Strongly disagree	1	0.2		
Overall Knowledge about pesticide handling practice	Poor	262	56		
	Good	206	44		

Source: Survey.

conducted, using univariable analysis in binary logistic regression, as the outcome variable was categorized into good or poor practice. Variables that showed significance at a *P*-value of less than 0.25 were selected for further analysis in the adjusted analysis, which aimed to control for confounding variables. In the univariate analysis, variables such as age, sex, family size, educational status, farmland size in hectares, experience in vegetable farming, pesticide use, knowledge about pesticide handling, and attitudes toward safe handling practices displayed significance with a *P*-value of less than 0.25. Consequently, these variables were included in the final model.

In the final model, safe pesticide handling practices were significantly associated with the educational status of the farmers, their experience of vegetable farming, their experience of pesticide utilization, and their attitude toward safe pesticide handling practices. Accordingly, farmers with at least primary education status were two times more likely [AOR: 2.1, 95% CI: 1.25–3.54] to practice good handling practices than those who didn't attend any formal education. Experience with vegetable farming for 5 or fewer years was 2.4 times more likely [AOR: 2.4, 95% CI: 1.53–3.88] to practice good handling than their counterpart. Similarly, farmers who had 2 or more years of experience with pesticide use were 4.7 times more likely [AOR:

Table 7. Factors associated with safe pesticide handling practices among vegetable farmers in selected districts in Jimma zone, 2023.

VARIABLES	CATEGORIES	PESTICIDE HANDLING PRACTICE		CRUDE OR		ADJUSTED OR	
		GOOD	POOR	COR, [95 % CI]	*P*-VALUE	AOR, [95% CI]	*P*-VALUE
Age category in years	Less than 40	78	123	1	.009	1	.075
	40 & above	136	131	1.64, [1.13-2.37]		1.55, [0.95-2.51]	
Sex	Female	17	29	1	.21	1	.268
	Male	197	225	1.49, [0.79-2.80]		1.53, [0.72-3.23]	
Family size (members)	Less than 5	85	129	1	.017	1	.703
	5 & above	129	125	1.56, [1.08-2.26]		1.10, [0.676-1.786]	
Educational status	No formal education	49	79	1	.048	1	.005*
	At least primary and above	165	175	1.52, [1.004-2.30]		2.10, [1.25-3.54]	
Land size in Hector	Less than one	104	144	1	.08	1	.66
	One and above	110	110	1.38, [0.96-1.99]		0.89, [0.54-1.48]	
Duration since participating in vegetable farming	5 years and above	81	130	1	.004	1	<.001*
	Less than 5 years	133	124	1.72, [1.19-2.49]		2.44, [1.53-3.88]	
Duration since using pesticide	Less than 2 years	13	56	1	<.001	1	<.001*
	2 years and above	201	198	4.37, [2.32-8.25]		4.68, [2.29-9.56]	
Knowledge	Poor	88	174	1	<.001	1	.865
	Good	126	80	3.12, [2.13-4.55]		1.05, [0.58-1.93]	
Attitude	Unfavorable	76	181	1	<.001	1	<.001*
	Favorable	138	73	4.50, [3.05-6.65]		4.17, [2.32-7.48]	

*Significant at *P*-value less than .001.

4.68, 95% CI: 2.29–9.56] to practice good handling than the less experienced farmers. The farmers who had favorable attitudes were also 4.2 times more likely [AOR: 4.17, 95% CI: 2.32–7.48] to practice good pesticide handling than those with unfavorable attitudes (Table 7).

Discussion

This community-based cross-sectional study was conducted to assess safe pesticide handling practices and factors associated with good handling practices in low-income settings, particularly in southwest, Ethiopia. The level of safe handling practices among the farmers was good for 45.7% [95% CI: 41.2%–50.2%] of the respondents. This study revealed that more than half of the respondents handle pesticides in unsafe conditions that expose them to different health risks. The level of safe pesticide handling practice in the study was higher than the results from Gondar, North Ethiopia, in 2023, 24.4%,[7] and in 2019, 36.2%.[25] On the other hand, it was lower than the study finding from Bahir Dar city (61.3%), North West Ethiopia.[9] The variation may be attributed to the control intervention variations.

The practice of safe pesticide handling was found to have significant associations with the educational status of farmers, their experience in vegetable farming, their experience in pesticide utilization, and their attitudes toward safe pesticide handling practices. Specifically, farmers with a minimum of primary education were twice as likely (AOR: 2.1, 95% CI: 1.25–3.54) to adopt good handling practices compared to those who did not receive any formal education. These findings align with previous research conducted in North Ethiopia,[7,25] Thailand,[26] and Nigeria,[27] which explain that good handling practices are influenced by the educational level of the pesticide handlers. This is because educated individuals have more insights into the risks and consequences of toxic compounds than those with low educational status.

The findings of the present study indicate a significant relationship between farmers' experience in farming activities and pesticide use, and their adherence to safe pesticide handling practices. Specifically, farmers with a maximum of 5 years of experience in vegetable farming were 2.4 times more likely (AOR: 2.4, 95% CI: 1.53–3.88) to engage in good handling practices compared to their counterparts. Similarly, farmers

who had 2 or more years of experience in pesticide use were 4.7 times more likely (AOR: 4.68, 95% CI: 2.29–9.56) to practice good handling compared to those with less experience. These findings are consistent with previous studies conducted in Ethiopia, supporting the observed association,[7,16] Nigeria,[27] and Thailand.[26] It may be explained that farmers learn the consequences and risks of pesticides through continuous observation, understanding their effects, and avoiding unsafe practices over time through self-learning and consistent observation.

The other significant factor was farmers' attitudes toward safe pesticide handling practices. The farmers who had favorable attitudes were also 4.2 times more likely [AOR: 4.17, 95% CI: 2.32–7.48] to practice good pesticide handling than those with unfavorable attitudes. The finding was also supported by similar studies from Ethiopia,[25,28] Nepal,[29] and Thailand.[26] This is because human action and behavior are based on willingness. The perceptions of the farmers lead to their actions. For instance, farmers who have a positive attitude may be encouraged to put the recommendations in the guidelines into action. On the other hand, those who have a negative attitude toward the action may not do it, even though it causes observable risks to their well-being.

The finding suggests that intensifying behavioral change education interventions targeted at farmers with low educational status and counseling may help reduce the risks related to unsafe handling practices. Additionally, the policy makers, including the Ministry of Health, the Ministry of Agriculture and Rural Development, and the Environmental Protection Authority, should work on integrated awareness programs to improve pesticide safety practices for farmers. Finally, because of the nature of the study, the self-reported handling practices may introduce recall bias, making it difficult to recall pesticides from a year or a month. Additionally, inaccuracies in reporting on pesticide chemical use history and experience may affect the results. The future research may benefit from focusing on interventional longitudinal studies targeted to the solutions.

Conclusions

In conclusion, the study revealed that about five in nine farmers engaged in vegetable farming in the study area have poor pesticide handling practices, which will pose health risks to farmers, consumers, and the ecosystem. The study revealed significant associations between factors like educational status, farming experience, pesticide utilization experience, attitude toward safe practices, and a lower level of safe handling practices. In order to mitigate the risks arising from unsafe pesticide handling practices, future interventions should address these factors, with a specific focus on raising awareness and providing close supervision for farmers with limited pesticide utilization experience.

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Author Contributions

HH: methodology, formal analysis, visualization, original draft writing, and reviewing the manuscript. SM: methodology, formal analysis, visualization, writing review, editing. SF and HA: methodology, formal analysis, visualization, writing, review editing. All the authors read and approved the final version.

Ethical Approval and Consent to Participate

Ethical approval to conduct this research was obtained from the Jimma University Institute of Review Boards (IRB) of the University of South-West Ethiopia. Written informed consent was obtained from the study participants. All subjects voluntarily participated in the study.

Availability of Data and Materials

The data sets analyzed during the current study are available in the supporting information.

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