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Chapter

Limited Knowledge and Unsafe Practices in Usage of Pesticides and The Associated Toxicity Symptoms among Farmers in Tullo and Finchawa Rural Kebeles, Hawassa City, Sidama Regional State, Southern Ethiopia

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Abstract

The insufficient knowledge regarding safe and proper pesticide handling by farmers in developing countries has led to extensive agricultural expansions at the expense of the health of farmers. The objective of this study was to assess the knowledge and field practices of farmers regarding pesticide handling, and to determine the prevalence of acute and chronic health-related problems in Finchawa and Tullo rural Kebeles of Hawassa City Administration. A cross-sectional mixed methods research design was employed to capture the fuller image of the issue. Farmers' knowledge regarding pesticide handling and toxicity found to be on average. The odds of the knowledge concerning proper pesticide handling was positively influenced by the factor of age, access to training; and years of experience; Field practices adopted by farmers were disappointing and intentional suicide incidents among teenagers were the result of farmers' unsafe storage. Nearly all the farmers did not use any means of PPE, and the lack of awareness about the dermal route presented a high risk of exposure. The common self-reported toxicity symptoms experienced by the participants included a headache (84.93%) and slow heartbeats (72.60%). The odds of prevalence of long-term toxicity symptoms found to be negatively correlated with the training factor while the same was positively influenced by the working hours in the farm. The study revealed that there is a high risk of exposure among farmers and their families in the study area.

Keywords: farmers, knowledge, unsafe practices, awareness, Toxicity symptoms, exposure

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1. Introduction

1.1 Background of the study

In parallel with the line of feeding 9.8 billion people by 2050, agricultural productions are largely expanding and intensifying [1]. The agricultural sector that made a living for 65% of poor working adults living in the developing world [2], includes the largest segment of society afflicted with the greatest amount of pesticide exposure [3]. Farmers and farmworkers put themselves at risk of pesticide poisoning during the production process [4]. They are routinely exposed to toxic pesticides via spray, drift or direct contact with pesticide residues on treated crops or soil [5].

Excessive and indiscriminate use of the most infamous synthetic organic chemicals, specifically chlorinated hydrocarbons like DDT, left a long-lasting imprint on every atom on earth since the beginning of the green revolution to date [6]. Despite the early alarming signs on the gruesome effects of these chemicals, such as the sharp decline of the bald eagle and other birds in the highest trophic levels of the food chain [7], the ascendency of using these chemicals pressed onward. This entailed unintentional pesticide exposure to the general population via food consumption [3, 8].

In Ethiopia, the agricultural sector is a source of livelihood for more than 80% of the population and represents more than three quarters of national exports [9], which impacts that almost 80% of the population in Ethiopia contributes to posing negative health issues to both humans and the environment, leading to the prevalence of acute and chronic health issues among people in the whole population [10, 11]. Hence, addressing this problem will have practical benefits for Ethiopia and will contribute to understanding of this widespread phenomenon among farmers almost in the whole country.

Unsafe practices exhibited by farmers in Ethiopia included the frequent mixing of highly toxic pesticides, unsafe storage and unsafe transport methods [12], unsafe disposal of empty pesticide containers [10], spraying while barefooted, using obsolete pesticides [13], selling illegal, expired, hazardous, unknown, repacked pesticides in small containers without any labeling, manufacturing or expiry date by unauthorized and untrained people in shops and local village in open markets [13], reusing empty insecticide containers for food and potable water, washing pesticide-contaminated work clothing with the family clothes and using highly toxic insecticides to treat head lice, fleas, bedbugs, and even to try to cure open wounds using malathion and (DDT), sometimes with fatal results [14].

Few researches in Ethiopia were conducted concerning the same area of study [10–12, 15], and further studies about pesticide use and pesticide-related illnesses are needed to develop more effective approaches for protecting farmers from pesticide exposure and moving the targets towards organic farming, resulting in having a healthy community free of disabilities and other dysfunctional diseases.

2. Material and methods

2.1 Study area

The study was conducted at Finchawa and Tullo rural kebeles in Hawella Tula sub city, which is located in Hawassa City Administration, Sidama, Ethiopia. Tullo and Finchawa are considered the catchment area of Lake Hawassa. The area lies on 1728 meters above sea level. The land form is plain [16], and has tropical savanna climate with two seasons [17]. The mean annual temperature is 20.9 °C with mean rainfall 997.6 mm [17]. The type of soils around Lake Hawassa in general is Andisols. A source of information about the type of soil in the study area is Hawassa University, Agricultural Campus. The two main crops cultivated in both areas are corn and ensete.

2.2 Study design and data collection tools

A cross-sectional survey with both qualitative and quantitative data collection research design were employed. The study was conducted between June and September 2020. The study also applied concurrent triangulation in data collection, where both qualitative and quantitative data were collected in one phase of the research study and equally weighted. A concurrent triangulation procedure is the model mostly employed when researchers first consider mixed methods as it results in a shorter data collection time period [18]. The three different primary data sources used in this study were a standardized questionnaire, key informant interview and a document review.

2.3 Methods of data collection

A supportive letter was given from the College of Natural and Computational Science, Biology Department, Hawassa University, to get the permission of the respective directions to select the study participants and conduct the interviews in extension offices, health institutions and hospitals. Two days of training were allocated to train four experienced data collectors. The training focused on explaining the purpose of the study, the meaning and interpretation of some scientific terminologies in each question, and obtaining consent from every single participant. The data collectors were experienced and capable of speaking the local languages (Amharic and Sidamingia). The four data collectors conducted door-to-door visits based on a list of members of the households to get responses and fill in the questionnaire. The list of householders was coded and their names were not mentioned for anonymity and confidentiality. In-depth interviews with officials and physicians were conducted by the researchers with the help of a professional translator who spoke both Amharic and English languages.

2.4 Data analysis

All data was coded and analyzed using SPSS version 25. Descriptive statistics were used to summarize frequencies and proportions, and results were presented in tables and charts. A multiple logistics regression model was employed to determine the effect of the independent variables on farmers' knowledge and the prevalence of self-reported toxicity symptoms. Multiple logistic regression was employed due to its powerful statistical way of modeling a binomial outcome for categorical data [19]. Chi-square, as well as Hosmer and Lemeshow tests, were firstly used before running the logistic regression test to measure the association between the independent and dependent variables and to check whether the model fits the data or not respectively. The data was summarized using the odds ratio, 95% confidence interval at .05 alpha levels.

2.5 Sampling technique and sample size determination

The study employed a multi-stage sampling technique due to the advantage it gives of using more than one stage and combine several sampling techniques. The multi-stage sampling in this study entitled four stages. In the first stage, the

Tula sub-city was purposively selected as it is relatively accessible by scientists. In the second stage, the Finchawa and Tullo rural kebeles were also purposively selected because of the considerable number of farmlands available in both kebeles, the extensive usage of pesticides in their farmlands, and their strategic location around Lake Hawassa. Both rural kebeles are considered the catchment area of Lake Hawassa. In the third stage, the study applied a simple random sampling to select farmers from both rural kebeles. All participants agreed to participate in the research study by signing informed consent forms. In the fourth stage, a convenience sampling was employed to select one official from the extension office in Finchawa, one official from the extension office in Tullo, one physician from the Bushullo Health Institution and one physician from the Referral Hospital.

The farmers' representative of both Finchawa and Tullo rural Kebeles estimated the number of farmers that use pesticides in their farmland as 100 farmers distributed as follows: Finchawa 49% and Tullo 51%. The sample size was determined by using the formula of Kothari [20]; at 95% level of confidence. Accordingly, the total sample including 10% of the contingency is 73.

2.6 Pilot testing

The questionnaire was piloted with 20 farmers (10 participants from Finchawa and 10 participants from Tullo) who did not participate in the study. Hence, all the forwarded comments regarding the wording of sentences, vague sentences and unclear scientific ideas were amended to ensure the validity of the items. The research was also expected to be reliable on its findings. Reliability of binary items were tested using Kuder–Richardson 20. The KR-20 can be applied to any test item responses that are dichotomously scored [21]. The value of internal consistency tests suggested a good level of reliability. Further, the internal consistency of the Likert scale items, was also tested using Chronbach's alpha. Cronbach's (1951) alpha was developed based on the necessity to evaluate items scored in multiple answer categories [21]. The value of internal consistency tests indicated a good level of reliability.

3. Results and discussion

3.1 Demographic characteristics of the respondents

As depicted in item 1 of **Table 1** below regarding male to female ratio, about 91.8% of the participants were males, while only 8.2% were females. The dominance of males over females in this study might be due to the nature of work as men usually are more involved in pesticide handling than women [22]. The sex ratio presented in this study is in line with the finding of [23].

Regarding the age of the respondents, about 50.7% had their ages between 36–45 years, while 20.5% and 16.4% were within the range of 46–55 and 25–35, respectively. The average age of the farmers was 44.42 years. The obvious decrease in the proportion of farmers on the both sides of the age spectrum might be due to youths' lack of interest in farming, in addition to their tendency to shift to urban areas for better employment and higher income [24]. The decrease may also be due to the health deterioration of aged farmers, as this limits their abilities to put up with more physical-consuming tasks that might add more health burdens to the bunch they already have.

Concerning the education status of the participants, the majority 65.75% had a formal education, mainly primary education 10.96%, secondary education 49.32%,

Variables	Category	Freq.	Percentage
Gender	Female	6	8.2%
	Male	67	91.8%
Age of the Respondent	25.00–35.00	12	16.4%
	36.00–45.00	37	50.7%
	46.00–55.00	15	20.5%
	56.00–70.00	9	12.3%
Educational Level	No formal education	25	34.25%
	First cycle primary (Grade 1–4)	8	10.96%
	Second cycle primary (Grade 5–8)	22	30.14%
	Secondary (Grade 9–10)	14	19.18%
	Preparatory and above level	4	5.48%
Years of Experience	Less than 5 years	12	16.4%
	5–10 years	25	34.2%
	10–20 years	20	27.4%
	20 years and above	16	21.9%
Average Monthly Income	<1000 birr	46	63.0%
	1001–1500 birr	14	19.2%
	1500 birr and above	13	17.8%
Residential Area	Living on the farm	48	65.8%
	Within 5 km distance from the farm	18	24.7%
	5–12 km away from the farm	7	9.6%
Is Farming	Your only source of income	32	43.8%
	You have another source (other job)	41	56.2%
Working Hours Per Day on the Farm	Part-timer <8 hours	41	56.2%
	Full-timer >8 hours	32	43.8%

Table 1.
Demographic characteristics of sample respondents (N = 73).

preparatory and above level 5.48%, while 34.25% of the participants were illiterates. Therefore, there is a considerable proportion of educated farmers in both kebeles and, the highest observations were categorized in the secondary education level. In comparison with similar studies that were previously conducted, there is a leap of improvement in the achievements of the educational sector in Ethiopia. A study done by [25] reported that only 24.3% of the sample participants completed their secondary level of education. Accordingly, the investment of the Ethiopian government in education through a sustainable increase in national expenditure and aids to the educational sector [26] is well translated in this study. Yet, more efforts are still needed to eradicate illiteracy completely, especially in the country sides.

With respect to farmers' work experience, most of the respondents 34.2% had 5–10 years of farming experience, followed by 27.4% and 21.9% of the same with 10–20 years and over 20 years of experience, in that order. Conversely, only 16.4% of the study participants had less than 5 years of experience. This clearly shows that most of the farmers in the study area had quite adequate experience which, in other studies, proved to have a significant contribution to good pesticide knowledge and safe practices [23, 27].

Majority of the respondents 63% earned less than 1000 Ethiopian birr, followed by 19.2% who earned 1001–1500 birr, while 17.8% of the respondents were found to earn 1500 birr and above. The low monthly income was also reflected by the study of [16] in Ethiopia.

About 65.8% of the respondents reported to be living on the farm, while 24.7% of the same replied that they are living within 5 km distance from the farm. On the contrary, 9.6% of the participants were living 5–12 km away from the farm. However, residing in or close to agricultural lands might increase the potential risk of pesticide exposure on farmers and their families through non-occupational pathways via spray drift and volatilization of pesticides beyond the treated area [28].

Majority 56.2% of the sample farmer respondents indicated that they have additional sources of income other than farming, while 43.8% of the same mentioned that farming is their only source of income.

Concerning the working hours per day, the majority of the respondents 56.2% indicated that they work as part-timers and they spend less than 8 hours per day on the farm, while 43.8% of the participants made known that they work as full-timers and they spend more than 8 hours on the farm. The low income of the majority of the respondents justifies the steep decrease in the proportion of youth in farming lands found in this study, and shows the modern-day slavery lifestyle which is portrayed in cheap wages beside the long working hours.

Accordingly, the socio-economic profile of the participants in both kebeles in this study indicated a kind of harsh lifestyle that swings in a range of difficult circumstances, including poverty, modern life slavery and illiteracy.

3.2 Farmers' knowledge regarding pesticides handling and toxicity

Participants were presented with eight questions that they could answer either "Yes or No". For the purpose of analysis, data was coded as (Yes = 1 and No = 0). The result showed that the total sum of the knowledge score was 288 with the mean and SD of knowledge score of 3.95 ± 1.07. The range of the knowledge score was 0 to 8 where: <4 = poor knowledge while ≥4 = good knowledge [23].

The sample farmer respondents were asked whether pesticides make people feel sick or not. Accordingly, the majority 56.2% of the farmers had a lack of awareness about pesticide use posing some potential risk to human health, while 43.8% of the respondents perceived that pesticides make people feel ill or sick. Similarly, the lack of awareness regarding the adverse health effects of highly toxic pesticides among farmers in the study area was also assured by the emergency physician in the Referral Hospital, who indicated during the interview that farmers would not store highly toxic pesticide in their homes if they were well aware about pesticide's fate in the environment and the negative health effects that pesticides might pose on humans. This finding is in line with the study of [29] which reported that 71% of the farmers had limited knowledge about pesticides posing a health problem in their community.

When inquired as to whether water gets polluted from pesticide runoff or not, about 35.61% of the respondents believed that the pesticides could pollute the aquatic environment, while the majority 64.39% of the respondents did not consider that the pesticide may affect the water bodies. The limited knowledge of farmers about the end fate of pesticides in the environment justifies the finding of [30] regarding the high concentration of DDT found in the *Barbus intermedius* fish, which represents the highest trophic level of the food chain in Lake Hawassa. However, the majority 67.12% of the farmers reported that contaminated water makes people sick or ill. This finding is in line with a previous study reported by [29] which stated that 91% of the farmers knew that water might get polluted from pesticide runoff, and people can get sick from water contaminated by pesticide runoff.

In item 4 of **Table 2**, participants were asked about the routes of which pesticides can enter their body. According to the data in **Table 2**, Inhalation 56.16%, followed by Oral 36.99%, Ocular 32.88%, and Dermal 12.76%. Conversely, considerable fraction 42.47% of the respondents did not know about the exposure route by which the pesticide could enter the body. However, despite the fact that dermal absorption is the main exposure route for pesticide appliers [31], it was the least route reported by respondents 24.66%. This rationalizes the high proportion of participants who reported to clean the contaminated area of skin after finishing their shift, rather than cleaning it immediately. The depiction of this action is illustrated in **Figure 1**. Moreover, this study noted that the majority of farmers were aware of the important entry routes of pesticide exposure, including inhalation and ingestion. These findings are in line with similar studies carried out by [32, 33].

Regarding farmers' knowledge of the effect of pesticides on food quality and quantity, about 71.2% of the respondents replied that pesticide application affects

Items	Category	Freq.	%
Do pesticides make people feel ill or sick?	No	41	56.2%
	Yes	32	43.8%
Does the water get polluted from pesticide runoff?	No	47	64.39%
	Yes	26	35.61%
Does contaminated water make people sick?	No	24	32.9%
	Yes	49	67.1%
Routes of which pesticides can enter your body? [Multiple responses possible]	Skin	18	24.66%
	inhalation	41	56.16%
	oral	27	36.99%
	Eye	24	32.88%
	Do not know	31	42.47%
Will the food be of the same quality without using pesticides?	No	52	71.2%
	Yes	21	28.8%
Can a farmer obtain the same yields without pesticides? (Quantity)	No	31	42.5%
	Yes	42	57.5%
Would people get sick if they entered the farm after a few hours of spraying (2–3 hours)	No	52	71.2%
	Yes	21	28.8%
Do you know about biological and natural control?	No	18	24.66%
	Yes	55	75.34%
What kind of pesticides do you use? [Multiple responses possible]	Insecticide	43	58.90%
	Herbicide	57	78.08%
	Fungicide	14	19.18%
	Rodenticides	3	4.11%
Knowledge status	Poor	24	32.12%
	Good	49	67.12%

Table 2.
Farmers' knowledge of pesticide handling and toxicity (n = 73).

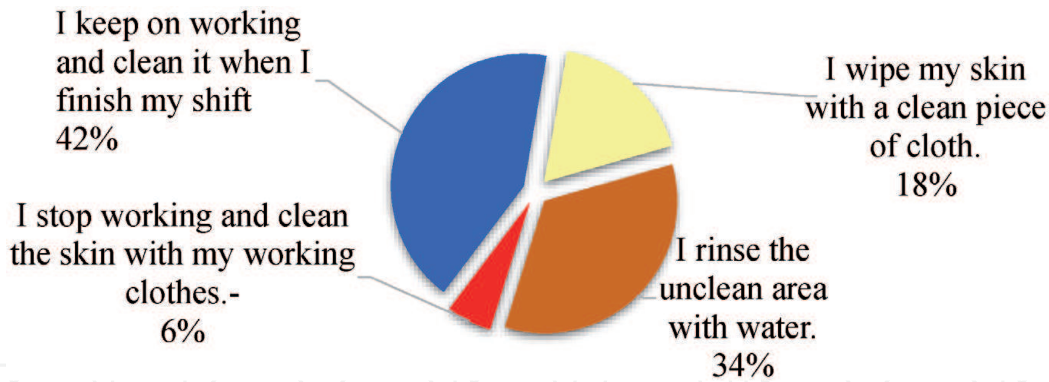

Figure 1.
Actions farmers usually take when their skin gets in contact with pesticides.

food quality. In contrast, 28.8% of the study participants disagreed with the stated statement. However, studies proved that pesticide application brings a primary benefit of better quality on crops, and this quality brings a benefit that outweighs the potential risk of human's exposure to very low residues of pesticides, especially in a diet containing fresh fruits and vegetables [3].

Regarding the effect of pesticides on crop quantity, about 42.5% of the farmers indicated that pesticides application is essential for high crop yield and productivity, while the majority 57.5% contradicted the correlation between pesticide application and crop quantity.

Farmers' tendency to rely on pesticides application to speed up the eradication of pest infestation is evident in this study. This reflects the high influence of the government on their officials perception, as the Ethiopian government extension program encourages the use of pesticides in agriculture and supports the widely-accepted perception that there is no other alternatives to pesticides [13].

Concerning whether people get sick if they entered the farm after a few hours of spraying (2–3 hours) or not, about 28.8% of the respondents perceived that pesticides make people feel ill or sick if they entered the farm after a few hours of spraying (2–3 hours), while 71.2% of the respondents did not relate any significant health effect to the exposure of pesticides. Farmers who re-enter treated fields soon after pesticide application might be in serious risk of exposure, especially when safety measures are poorly adopted [4].

Participants were also asked whether they know about biological and natural control or not. Majority 75.34% of the farmers indicated that they know about biological and natural control of pesticides, while only 24.66% of the participants did not know about natural pest control. In similar vein, officials in the agricultural extension office mentioned during the interview that farmers had used tobacco leaves as pest repellant and added healthy soil to the infested one when they are confronted with a shortage of pesticide availability. The aforementioned findings concerning farmers' knowledge about biological and natural control correlate with similar statements made by their authorities.

Insecticides 58.90% and herbicides 78.08% are the most common types of pesticides utilized in this study, while fungicides 19.18% and rodenticides 4.11% were the least pesticides used. Authorities from the agricultural office also indicated that the three main pesticides used in both kebeles are endosulfan to eradicate aphids, diazinone to combat American bollworm, and flazasulfuron to control the growth of the unwanted weeds. These responses strongly suggest that farmers and local authorities are in agreement on the use of the above-mentioned agents.

Regarding the training that is regularly given for the participants in both Kebeles, the experts in the extension offices reported during the interview that:

> *'We visit farmers in their farmlands about three times per week, and in addition, we keep on giving them professional training and instructions regularly.'*

Despite the efforts excreted by the experts in the extension offices in both Kebeles regarding the proper communication and the regular training they give to farmers in their farmlands, there is a limited knowledge among the participants about the effects of pesticides on humans' health and the environment, in addition to the lack of awareness regarding the dermal route of exposure. Accordingly, the training given to the sample participants in the study area is in insufficient, and different strategies should be taken to improve the process of learning and further mitigate their risk of exposure.

3.3 Factors that influence farmers' knowledge regarding pesticide handling and toxicity

The study also Investigated the factors that influenced farmers' good knowledge regarding pesticide handling and toxicity. Accordingly, item 2 of **Table 3** revealed that the odds of the knowledge are positively influenced by the age factor; therefore, older farmers are 1.377 times more likely to have a good knowledge regarding pesticide handling and toxicity, than those who are younger. The estimated odds ratio is statistically significant since ($p = 0.002$) which indicates that ($p < 0.05$) is within a 95% confidence interval (OR = 1.377, CI = 1.125–1.685). Therefore, acquiring domain knowledge through aging might be due to daily observations and interaction with people who are knowledgeable and very well experienced in farming work.

Dependent variable: Good knowledge **Independent Variables**	**B**	**S.E.**	**Sig.**	**OR**	**95% C.I.**	
					Lower	**Upper**
Gender (1 = Male), Ref. = Female	0.584	1.342	0.664	1.792	0.129	24.864
Age of the respondent	0.320	0.103	0.002	1.377	1.125	1.685
Reference = no formal education			0.176			
First cycle primary (Grade 1–4))	1.207	1.330	0.364	3.344	0.246	45.377
Second cycle primary (Grade 5–8)	2.503	1.203	0.037	12.222	1.157	129.162
Secondary level (Grade 9–10)	2.799	1.230	0.023	16.436	1.476	183.046
Preparatory and above level (11+)	3.677	3.117	0.238	39.522	0.088	17769.305
Training in pesticides/ safety (1 = yes)	2.549	1.241	0.040	12.799	1.124	145.789
Experience (Ref. = > 5 years)			0.071			
5–10 years	3.455	1.434	0.016	31.649	1.903	526.455
10–20 years	2.726	1.333	0.041	15.278	1.121	208.284
Above 20 years	5.015	2.059	0.015	150.681	2.666	516.792
Constant	−18.148	5.348	0.001	0.000		

Table 3.
The multiple logistic regression analysis of factors that influence farmers' knowledge of pesticide handling and toxicity.

According to item 3, **Table 3**, the odds of knowledge is also positively influenced by farmers' educational level, especially with the second cycle primary (grade 5–8) and secondary level (grade 9–10) of education. Hence, farmers who achieved second cycle primary (grade 5–8) education level are (12.222) times more likely to have a good knowledge in pesticide handling and toxicity, than those who did not achieve this level of education since ($p = 0.037$) which indicates ($p < 0.05$). The estimated odds ratio is statistically significant within a 95% confidence interval (OR = 12.222, CI = 1.157–129.162). A similar analysis showed that farmers who attended secondary level (grade 9–10) of formal education are 16.436 times more likely to have good knowledge in pesticide handling and toxicity than those who did not achieve this level of education since ($p = 0.023$) which indicates ($p < 0.05$). The estimated odds ratio is statistically significant within a 95% confidence interval (OR = 16.436, CI = 1.476–183.046).

Regarding farmers' access to training which is presented in item 4 of **Table 3**, the odds of knowledge status is positively influenced by the training factor since ($p = 0.040$) which indicates that ($p < 0.05$). Thus, farmers who attended field training are 12.799 times more likely to have a good knowledge in pesticide handling and toxicity than those who did not take any training. The estimated odds ratio is statistically significant within 95% confidence interval (OR = 12.799, CI = 1.124–145.789).

Item 5 of **Table 3** also showed that the odds of the knowledge were positively influenced by the experience factor, Accordingly, farmers who had 5–10 years of work experience are 31.64 times more likely to have a good knowledge in pesticide handling and toxicity than those who had less years of work experience since ($p = 0.016$) which indicates ($p < 0.05$). The estimated odds ratio is statistically significant with 95% confidence interval (OR = 31.64, CI = 1.903–526.455). In addition, farmers who had 10–20 years of work experience are 15.278 times more likely to have a good knowledge in pesticide handling and toxicity than those who had less years of work experience since ($p = 0.041$) which indicates ($p < 0.05$). The estimated odds ratio is statistically significant with 95% confidence interval (OR = 15.278, CI = 1.121–208.284). The result also indicated that farmers who have 20 years of work experience and above are 150.681 times more likely to have a good knowledge in pesticide handling and toxicity, compared with the reference category (Ref. < 5 years) since ($P = 0.015$) which indicates ($p < 0.05$). The estimated odds ratio is statistically significant within 95% confidence interval (OR = 150.681, CI = 2.666–516.792), while gender and first cycle primary (grade 1–4) failed to be significant predictors under the given conditions.

3.4 Farmers' field practices including storage, disposal, transportation and pesticide preparation

The study evaluated farmers' field practices by assessing the way they disposed of empty pesticide containers, the way they transported pesticides from the vendors' shop to the field, the way they stored pesticides and their spraying equipment, and their methods of pesticide preparation.

3.4.1 Disposing empty chemical containers by farmers

About 12.33% of the participants reported burning empty pesticide containers as a method of disposal. The guidelines on the management options for emptying pesticide containers by [34] warned against and manifested on the prohibition of such practice. Open burning of pesticide containers generates environmentally-persistent toxic fumes resulting from chemical traces lining the container, chemicals which are used to make the body of the container, or emissions of incomplete combustion. Such toxic fumes might be inhaled by animals or humans that exist in the burning area, causing irreversible damage to health.

The majority 64.38% of the farmers reported reusing empty pesticide containers for other purposes, like water or food storage. Reusing empty pesticide containers might increase the risk of non-occupational exposure via pesticide residuals ingestion as it is impossible to remove all traces of pesticide chemicals' residue from empty plastic or metal pesticide containers [35]. According to [36], empty pesticide containers should be shaken clean and triple-rinsed before disposing them in an environmental-friendly manner.

The fact that the majority of the farmers reuse empty pesticide contains for food and water storage is worrisome, and might be a result of a wrong perception that once the container is washed, it becomes pesticide-free and poses a zero negative health effect on them. This perception might be acquired from their daily observations as they did not suffer or saw anyone complain of any negative health effects on the short-term of ingestion. Hence, it is very obvious that farmers are unaware of the long-term risks of pesticide exposure and the adverse health effects these residuals might pose when they accumulate in body tissue. Reusing empty pesticide containers by majority of the participants was also reported by the study of [12].

About 10.96% of the participants disposed their empty pesticide containers anywhere on the farm. Such improper disposal method contaminates the soil with chemicals that might leach to both ground and surface water, or reach the latter via surface runoffs, posing a threat to aquatic organisms, as well as humans that use ground water for drinking.

Dropping pesticide containers in a public dump was reported by 5.4% of the sample participants. Such practice might expose solid waste collectors in the formal and informal sector to unintentional exposure via skin contact, inhalation or ingestion, especially those workers do not use any means of protection measures to avoid several safety issues they experience on a daily basis. Moreover, a considerable proportion of the workers in the informal sector are children who might take the containers, wash them improperly, and reuse them for water drinking or sell them to people in the local market.

In Finchawa, reusing pesticide containers was not limited to illiterate people. The official from the agriculture office who had 7 years of work experience in agriculture, a university degree and a robust background in farming, recommended and instructed farmers to reuse empty pesticide containers. Further, officials in Tullo kebele instructed farmers to dispose empty pesticide containers in pit latrines. When the latrines are full, they are backfilled and new pits are dug again.

Pit latrines usually lack a physical barrier that separate human's excreta or chemicals thrown in the pit and soil or ground water. Therefore, contaminants from latrines potentially leach into ground water and seeps into other water surfaces, like lakes or rivers, posing a threat to humans using ground water or aquatic organisms living in water bodies [37].

Encouraging farmers to reuse empty pesticide containers, or throw them in latrines by officials, might be a part of the kebeles' waste management strategy to reduce environmental contamination and save water sources due to the lack of availability of proper disposal facilities in Hawassa. Yet, it is strong evidence of poor understanding and a lack of awareness about the effects of pesticide residues that come in contact with food and drinking water, the long-term health effects on humans, and the negative impacts of pesticides on the environment.

Throwing empty pesticide containers in the lake by 6.85% of the participants is presented in item 5 of **Table 4**. According to [38], once pesticides reach water

No	Items	Freq.	Percent
1	Burn	9	12.33%
2	Reuse them for food and water storage	47	64.38%
3	Throw them anywhere in the farm	8	10.96%
4	Drop in the public dump	4	5.4%
5	Throw in the lake	5	6.85%
Total		73	100%

Table 4.
Disposal methods of empty pesticide containers by farmers.

bodies, they can impact the whole ecological food chain, since other animals, including humans, feed on aquatic animals that may be contaminated.

Back to the literature review, recalling the Lake Michigan incident about children who had an intellectual impairment due to their in-utero exposure to organochlorines [39], in addition to the finding of [40], several cases of learning disabilities, autism, ADHD, child cancer and juvenile diabetes among the generation living around the lake, and consuming food and water contaminated with highly toxic pesticides in the 30–40 coming years, is expected by this study. The increment in the rate of suicide incidents among teenagers that was reported by [40] was also reported and manifested by the physician of the emergency room in the Referral Hospital.

3.4.2 The way farmers transport pesticides from the shop to the farm

Respondents were asked about the way they transported pesticides from the store to the farm. Accordingly, the majority 42% of respondents indicated that they carry it and walk, while the rest used the bed of a truck alone with no other items 22%, the backs of donkeys 18% and bajaj with other passengers 18% (**Figure 2**).

Using the backs of donkeys, public transport or self-carrying methods to deliver pesticides from shop to field are inappropriate pesticide transport practices that might expose human beings, animals and the environment to danger, in the case of unexpected accidents during trips. Such accidents might cause a container puncture, break or torn which increase the risk of spillage. However, spillage or leakage of highly toxic pesticides might be absorbed through inhalation or directly through unbroken or broken skin. Unfortunately, delivering pesticide containers using the bed of the truck alone with no other items was reported only by 22% of the participants.

3.4.3 Storage of pesticides and spraying equipment by farmers

Farmers' practices on storing pesticides and spraying equipment were assessed through 5 items. Almost all of the farmers 98.63% reported that they frequently take the spraying equipment after the field work to their home. A considerable proportion of farmers 79.45% reported storing pesticides in the bedrooms, 60.27% in the living room, and 63.01% in the kitchen. However, storing pesticides beside food, potable water or seeds may increase the risk of their contamination with vapors, dust or spills, and increase the likelihood of accidental human exposure (**Table 5**).

Frequent intentional suicide incidents among teenagers and youths in their early twenties in both kebeles were reported by the physician in the emergency room at the Referral Hospital during the interview due to the free availability of pesticides

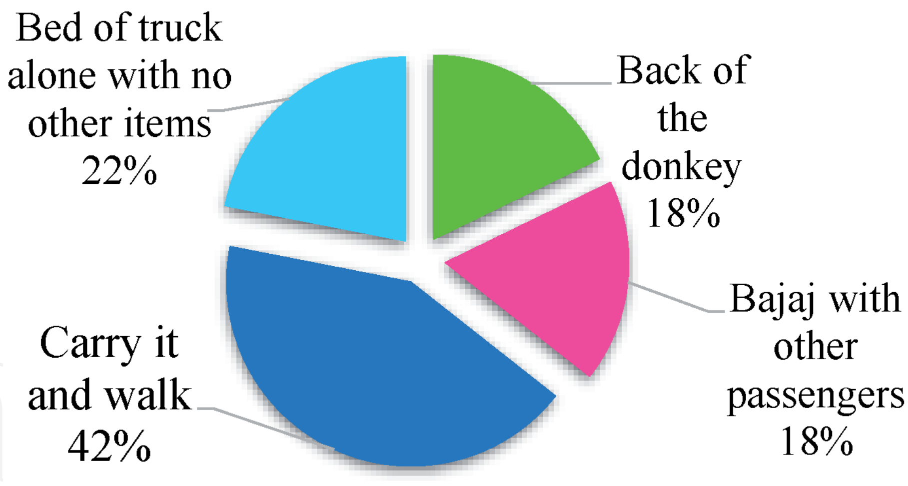

Figure 2.
Means of transporting pesticides from the store by farmers.

Items	No	Yes
Do you usually take the spraying equipment after the field work to your home?	1 1.37%	72 98.63%
Have you ever stored pesticides in the bedroom?	15 20.55%	58 79.45%
Have you ever stored pesticides in the living room?	29 39.73%	44 60.27%
Have you ever stored pesticides in the kitchen?	27 36.99%	46 63.01%
Do you store pesticides in a locked and separate place that is specified for pesticide storage?	36 49.32%	37 50.68%

Table 5.
Storage of pesticides and spraying equipment by farmers.

in farmers' houses. The rate of suicide cases among the mentioned segments is 3–4 cases per month (around one case per week). The physician at the Referral Hospital indicated that organophosphate is the most commonly used insecticide in both kebeles.

The official in Finchawa reported that farmers use diazinone and endosulfan to eradicate bed bugs in their homes, which exposes them and their families to a high risk of exposure via direct inhalation, especially that Endosulfan evaporates rapidly after spraying and poses high toxicity if inhaled on the long-term of exposure [41].

Unfortunately, only 50.68% reported that they store pesticides in a locked and separate place that is specified for pesticide storage.

Methods of pesticides' storage among farmers in both kebeles found to be inappropriate in this study. Moreover, it increased the risk of exposure on farmers and their families through direct and indirect ingestion, inhalation or dermal absorption.

3.4.4 Preparation of pesticides by farmers

The sample participants were asked about the likelihood of using a measuring cup or measuring tool to add the exact amount of pesticide mentioned on the label.

Accordingly, the majority 97.25% of the farmers reported that they never or rarely use a measuring tool to add the exact amount of pesticide mentioned on the label, while 2.73% responded sometimes.

The failure of using a gauging tool to measure the amount of pesticide needed for the application, results in using a less or more dose of pesticide than the one recommended on the label. The result of frequently low or heavy doses of the application is more resistance, more pest resurgence and more secondary outbreaks. Moreover, heavy doses of the application lead to an unacceptable environmental contamination and high risk of human exposure. One study reported that only 0.0000001% of DDT reach the target pest, while more than 99.99% are dispersed into the environment through volatilization, surface runoff, infiltration and drift [42]. This finding is in line with the result of [11] which indicated that none of the farmers used scaled measuring equipment.

Practices	Never	Rarely	Some times	Often	Always	Mean	SD
Do you usually use a measuring cup or measuring tool to add the exact amount of pesticide mentioned on the label?	66 90.41%	5 6.84%	2 2.73%	0 0%	0 0%	1.12	0.41
How often do you check the defect (inadequacy) of the spraying equipment you are using before you start applying?	23 31.5%	9 12.3%	38 52.1%	3 4.1%	0 0.0%	2.25	1.32
Do you usually check the defect (inadequacy) of the PPE before dealing with pesticides?	56 76.72%	15 20.55%	2 2.73%	0 0%	0 0%	2.29	0.96
Do you use special tools (only for pesticide usage) to mix and apply pesticides?	32 43.8%	8 11.0%	23 31.5%	3 4.1%	7 9.6%	1.26	0.50
Average	177 60.62%	37 12.67%	65 22.26%	6 2.05%	7 2.40%	1.73	0.50

Table 6.
Farmers' pesticides handling and preparation.

Participants also were asked about the likelihood of checking the inadequacy of the spraying equipment before they start applying pesticides. About 43.8% of the farmers reported that they never or rarely checked their spraying equipment before they start applying, while 52.1% responded sometimes, with 4.1% reporting that they often check the inadequacy of the spraying equipment before they start applying. However, punctures, breaks and cracks in the tank of the spraying equipment for liquid formulation results in a high risk of exposure to workers via dermal absorption.

Majority 97.72% of the participants reported that they rarely or never checked the defect of their PPE before dealing with pesticides because PPE are mostly unavailable, while 2.73% only reported doing such practice sometimes.

Participants were asked if they usually use special tools to mix and apply pesticides. The majority 54.8% reported that they never or rarely used special tools to mix and apply pesticides, rather, they use their hands or any available stick in the farm for the purpose of mixing. About 31.5% indicated that they sometimes used special tools to mix and apply. The rest of the participants reported often 4.1% or always 9.6%. Mixing pesticides with hands increases the risk of exposure via dermal absorption or ingestion as farmers can easily carry traces of pesticides from their hands to their mouth, especially in the case of poor usage of PPE that was reported by this study. This finding is in line with the result of [13].

Statistically, it is also observed from the results in **Table 6** above that the mean average score of the participants' responses 2.27, 2.25, 2.29, and 1.26 regarding the methods of pesticide preparation is below the average Likert scale 3. This indicates that the farmers are not in a position to reduce the risk of pesticide exposure.

As depicted in **Figure 3** below, respondents were asked about the source of information before and during mixing, applying or loading pesticides. Accordingly, the majority of the farmers 72% got information from kebeles' agricultural experts, while the minority of the farmers 17% reported that they get such information from their neighbors or 11% vendor. Despite the considerable proportion of the participants receiving information from kebeles' agricultural experts, it is disquieting to have 27% of the respondents seeking information from improper sources. Studies proved that there is a big difference between experts and novices in the way they perceive, remember and express their observations through the language they use [43]. Hence, seeking information from neighbors or vendors about the kind of

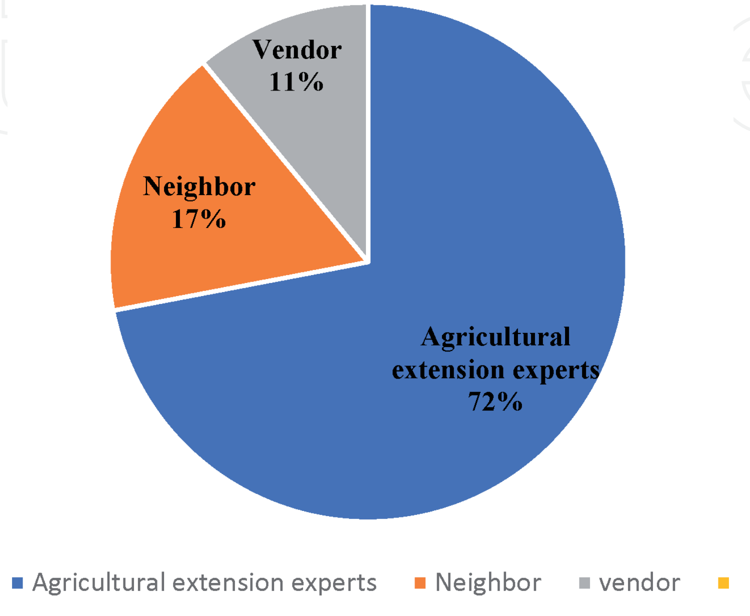

Figure 3.
Farmers' sources of information while mixing, applying or loading pesticides.

pesticide should be used, or any technical issue regarding pesticide handling results in farmers' information inadequacy.

Officials in the agricultural office in both kebeles assured, during the interview, that farmers resort to them when they observe any pest infestation in their farms to get advice about the right type of pesticide that should be applied in such cases. This implies that participants are somehow on the same page with their authorities. This finding is in line with the result of [44] which reported that 57.2% of the farmers seek information from woreda agricultural extension experts.

As depicted in **Figure 4** below, respondents were also asked about the area they usually use to mix and load pesticides. The majority 56% of the respondents reported that they mix and load pesticides within their residential area in the garden, while 27% reported that they mix and load in the field and 17% reported that they never prepare pesticides and they use the one that is already prepared by someone else. Mixing and loading pesticides within the house garden increases the risk of exposure of farmers' family members via dermal absorption, inhalation or ingestion, especially among small children who spend most of their time outdoors playing with the mud.

The inadequate knowledge of farmers regarding pesticide handling and toxicity was reflected in their field practices and found to be unsatisfactory. Moreover, it implied a high potential of pesticide exposure for them and their families.

3.5 Safety precaution and protective measures adopted by farmers

3.5.1 The usage of personal protective equipment by farmers

The usage of PPE by farmers while dealing with pesticides was assessed in this study. Nearly all the participants 93.15% did not use any means of PPE while dealing with pesticides and 6.85% of the respondents only reported using gloves.

This indicates that farmers are in a high potential risk of exposure while preparing, handling and spraying pesticides through all the exposed parts of their bodies,

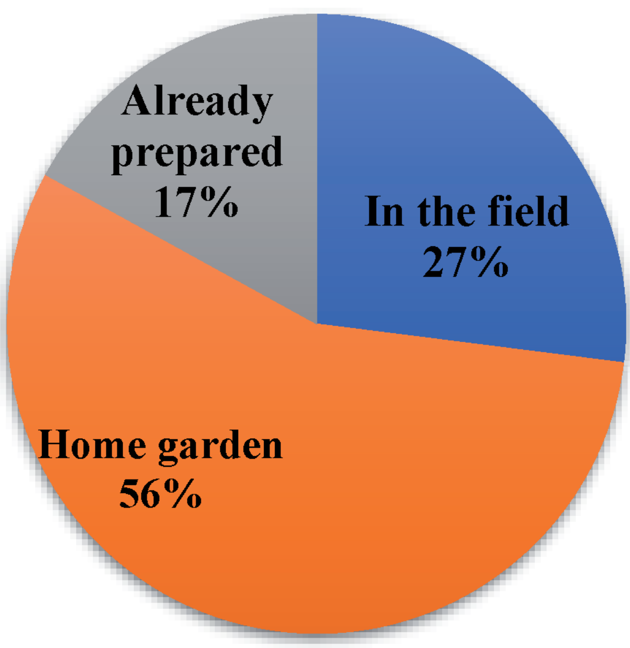

Figure 4.
Pesticide preparation area by farmers.

especially their hands, which are considered the main carriers of pesticide, traces to every single part of their bodies. Wearing proper PPE during pesticide application proved to have a significant effect on mitigating farmers' risk of exposure. According to [45], an increase in the use of protective measures decreases the probability of poisoning by 44% to 80% (**Table 7**).

Farmers were also asked to list the factors that stops them from using PPE while handling pesticides. As depicted in **Figure 5** below, the answers were as follows: too expensive 42%, not comfortable in the tropical climate 5%, not available when needed 22% and no health challenges from using pesticides 31% are some of the cited reasons.

The officer in Finchawa Kebele reported during the interview that farmers do not use any kind of personal protective equipment while dealing with pesticides because the government does not provide them with any. However, the officer in Tullo indicated that farmers tie their clothes on their nose and mouth while spraying as a kind of precautionary measure to protect themselves from pesticide exposure, which increases the risk of their dermal exposure after wearing their clothes again.

3.5.2 Instant actions taken by farmers when their skin gets in contact with pesticides

The study assessed the actions that farmers take instantly when their skins get contaminated with pesticides. As depicted in **Figure 1**, sample respondents were asked about the actions they take when their skin gets in contact with pesticides. Accordingly, about 18% of the respondents reported that they wipe the unclean area of skin with a clean piece of clothing, while 6% indicated that they stop working and clean their skin with working cloths, and 34% replied that they rinse the pesticide-contaminated area of skin with water. However, the majority of the respondents 42% reported taking no action until they finish their shift **Figure 1**.

Ignoring the contaminated area of skin with pesticides until the shift is finished, rather than cleaning it immediately, is worrisome. According to [46], the extent of skin absorption increases positively with the duration of exposure. This implies that the sooner the cleaning of the contaminated area of skin is performed, the greater the decrease in the dermal absorption is achieved, especially in the case of liquid formulations. Besides, the longer the operators ignore the stains of pesticide on their skin, the greater the risk of their exposure will become via the inhalation of pesticide volatiles.

No	PPE Items	Freq.	percent
1	Gloves	5	6.85%
2	Mask/Respirator	0	0%
3	Protective eyewear	0	0%
4	Special shoes	0	0%
5	Overall	0	0%
6	Hat/Cap	0	0%
7	Wear all of them at the time of handling pesticide	0	0%
8	Do not use any of them	68	93.15

Table 7.
The usage of personal protective equipment by farmers.

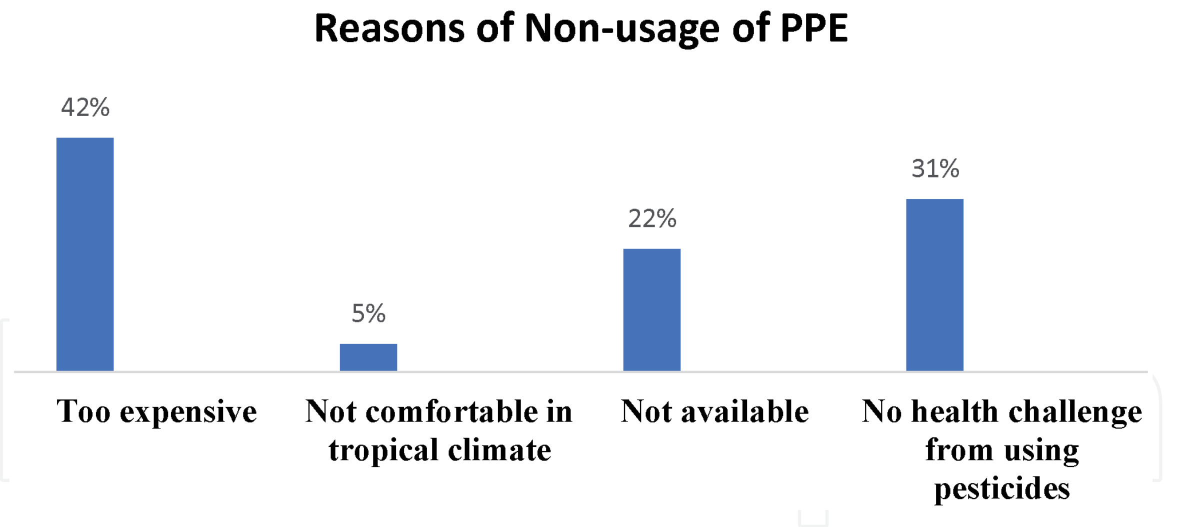

Figure 5.
Factors that hindered the usage of PPE by farmers.

Rinsing the contaminated area of skin with water is considered a proper action in the case of using water soluble pesticide formulation, like flazasulfuron, based on the general rule of like dissolves like. Yet, both organochlorine and organophosphate insecticides reported to be used in this study are lipid-soluble. They are very well absorbed through the skin as they dissolve easily in the sebum that is released by the sebaceous glands; therefore, rinsing the contaminated area with water is an inappropriate instant action performed by farmers and implies a high risk of exposure.

Wiping the contaminated area of skin with a work cloth is also worrying. Cloths soaked with pesticides increase the risk of dermal exposure and volatiles inhalation. Also, the longer the time the operator wears the contaminated clothes, the greater the extent of absorption and inhalation will be.

The level of self-protection among farmers regarding the proper usage of adequate PPE while dealing with pesticides, and the instant action taken when their skin gets contaminated with pesticides in this study, is found to be disappointing and presents a potential risk to pesticide exposure, especially via the dermal route.

3.6 Self-reported toxicity symptoms associated with pesticide exposure among farmers

Sample respondents were asked about the acute toxicity symptoms they experienced in 24 hours after mixing, loading or applying pesticides. Significant number 94.52% of the farmers reported at least one symptom of acute pesticide poisoning in the previous year immediately after applying or handling pesticides, while 5.48% of the respondents did not ascribe any health problems encountered to pesticide exposure. The most frequently symptoms reported by the participates were headaches 84.93%, skin rash 60.27%, slow heartbeats 72.60%, chest wheezing 67.12%, change in their mood 71.23%, dizziness 42.46%, burning in the skin or eyes 61.64%, lacrimation 17.81% and day/night coughing 23.29%. Other symptoms reported by respondents were pain in the hands or on the feet, excessive sweating and chest tightness (**Table 8**).

Participants were also asked about the actions they take following an incident of poisoning. The majority 53% reported that they resort to traditional methods like drinking milk, applying creams and washing the affected area, 32% reported that they do not take any action as long as the incident is minor or required only self-medication. Only 15% of respondents reported a serious poisoning incident that required medical attention in a clinic (**Figure 6**).

Items	Freq.	Percentage
Skin rash	44	60.27%
Headache	64	84.93%
Slow heartbeats	53	72.60%
Chest wheezing	49	67.12%
Burning in the skin or eyes	45	61.64%
Change in the mood	52	71.23%
Day/night cough	17	23.29%
Dizziness	31	42.46%
Excessive sweating	24	32.88%
Pain in the hands or in the feet	14	19.18%
Chest tightness	14	19.18%
Pain in the hands or in the feet	14	19.18%
Eye tears	13	17.81%
No health impairment	4	5.48%

Table 8.
Toxicity symptoms reported by the participants on the short-term of exposure.

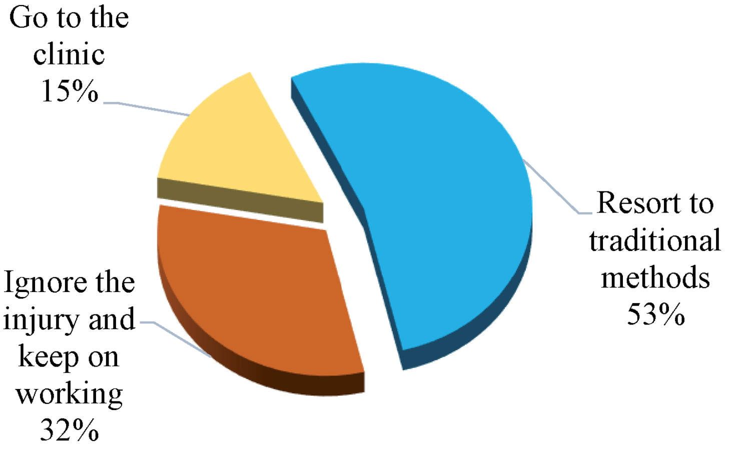

Figure 6.
Action farmers usually take following an incident of poisoning.

Self-medication methods that farmers resort to in the case of injury were manifested by the physician in the Referral Hospital during the interview.

> *Farmers usually drink milk after swallowing bleach (Barakina) to reduce the risk of injury.*

In general, actions taken by farmers following an incident of poisoning are unsatisfactory. Only a few of participants have visited a health institution after incidents of pesticide poisoning, and others resorted to traditional-based care methods or did not take any action. This finding is also in line with what the physician has indicated in the health institution. Similar findings were reported by the study conducted in Tanzania [47].

On the long-term of exposure, symptoms reported by farmers are illustrated in **Figure 7** below. The majority 46% of the sample respondents reported libido, whereas, the remaining reported poor memory 24%, diabetes 10% and others 20%.

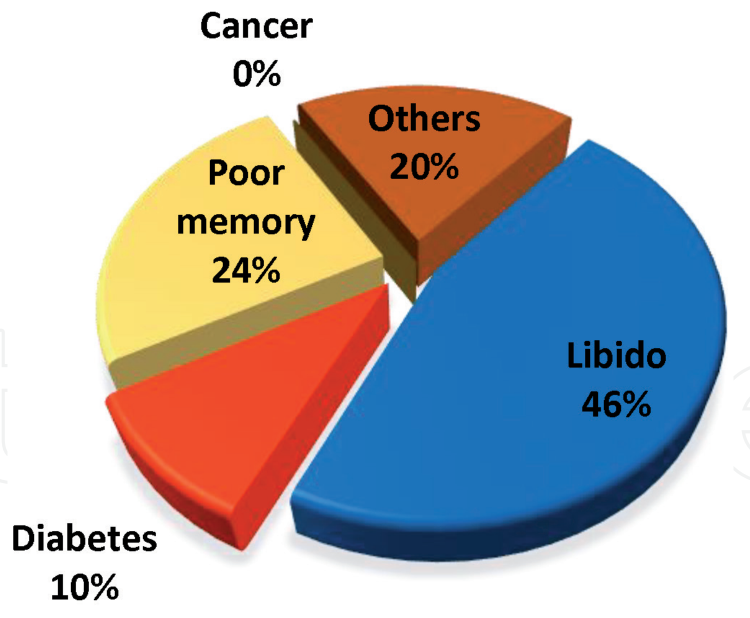

Figure 7.
Long-term health effects reported by farmers.

Through increasing the reactivity of toxic xenobiotics by converting them into electrophiles, free radicals or nucleophiles, chemicals cause damage to major biological systems leading to the development of various diseases, such as diabetes, neurodegeneration, schizophrenia, respiratory disorders, aging, cancer, immunodeficiency syndromes, and hypertension [48]. The ultimate toxicant may bind to the target molecules covalently or non-covalently, or may alter it by hydrogen abstraction, electron transfer or enzymatic reaction.

Endocrine disruptors, such as endosulfan, were proved to change the levels of insulin secretion in the body, leading to the development of diabetes [49]. Regarding men infertility, including libido, it was found that exposure to organochlorines is the main reason for hyperprolactinemia (a severe decrease in serum prolactin) which is the main reason for decreased libido and infertility [50]. Furthermore, a developmental exposure to pesticides may generate oxidative stressors that result in irreversible damage in the brain cells, followed by reducing the ability of the cells to communicate with each other. In time, chemical connections between brain cells are lost, and cells begin to die, resulting in poor memory [51].

The finding in the study revealed that the prevalence of toxicity symptoms among farmers is quite high.

3.7 Factors influence the prevalence of long-term toxicity symptoms among farmers

A multiple logistics regression model was employed to determine the effect of the independent variables (working hours per day, residential area, source of income, experience and training) on the prevalence of long-term toxicity symptoms among farmers (**Table 9**).

The result illustrated that the odds of the prevalence of long-term toxicity symptoms is negatively correlated with the training factor; therefore, farmers who have access to training are 9% less likely to develop long-term toxicity symptoms than farmers who did not attend training in pesticide handling and toxicity. Hence, the estimated odds ratio is statistically significant since ($p = 0.042$) which indicates that ($p < 0.05$) within 95% confidence interval (OR = .090, CI = 0.009–.0.920).

The result also revealed that the odds of the prevalence of long-term toxicity symptoms is positively influenced by working hours per day; therefore, farmers

Dependent variable: self-reported toxicity	B	S.E.	Sig.	Exp(B)	95% CI for EXP(B)	
					Lower	Upper
Training(1 = yes)	−2.406	1.185	.042	.090	.009	.920
Experience			.990			
Experience (1 = 5–10 years)	−.341	1.062	.748	.711	.089	5.697
Experience (2 = 10–20 years)	−.311	1.128	.783	.733	.080	6.682
Experience (3 = above 20 years)	−.362	1.257	.773	.696	.059	8.169
Working hours per day on the farm (1 = Full time)	2.681	.841	.001	14.599	2.809	75.881
Knowledge	−1.566	.828	.059	.209	.041	1.059
Constant	−.884	.838	.291	.413		

a. Variable(s) entered on step 1: training, Years of using pesticides (experience), working hours per day, and knowledge.

Table 9.
The factors that influenced the prevalence of long-term toxicity symptoms among farmers.

who work more than 8 hours per day in the farm (full-timers) are 14.599 times more likely to develop long-term toxicity symptoms than farmers who spend less than 8 hours in the farm (part-timers). Hence, the estimated odds ratio is statistically significant since ($p = .001$) which indicates that ($p < 0.05$) within 95% confidence interval (OR = 14.599, CI = 2.809–75.881), while knowledge and years of experience failed to be significant under the given conditions.

3.8 Data extracted from the interview with the physicians in Bushullo health center and referral hospital

The physician in the Bushullo health institution reported during the interview that:

> *"Only one acute pesticide intoxication case was reported for the last five years. The case was a female farmer and wasn't officially registered because she refused to pay the card fee which was 20 birr. The farmer patient was excessively salivating and dizzy when she arrived to the health center. Symptoms were quickly reversible and the patient returned back healthy in 15-30 minutes. Severe cases of acute pesticide intoxication are not treated in the health center and usually are transferred to the Referral Hospital because antidotes for poisons are not available in the health institution. The health institution treats patients with minor symptoms only by providing them with oxygen and fluids. Cases of pesticide intoxication were never under-estimated, and all the crew in the health institution resort to the Ethiopian hospital guidelines to diagnose all cases. In addition, doctors ask about the history of using pesticides as a part of the diagnosis."*

Both hard and soft documents where reviewed in the health center by the interviewed physician to obtain the accurate number of toxicity cases registered before.

The physician also indicated that under-reporting the cases by farmers is due to a lack of knowledge as most of the farmers are illiterates and the government's help would be appreciated by providing more educational programmes and training to farmers, and their families.

The interviewed physician in the emergency room at the Referral Hospital declared that:

"All pesticide intoxication incidents reported before were intentional suicide cases among teenagers and youths in their early twenties. Most of suicidal cases resort to the hospital when they reach the brink of death. Symptoms experienced by patients are vomiting, diarrhea, sweating, breathing difficulties, uncontrollable defecation and too much fluid around the lungs. The antidote usually given in these cases is atropine as it rapidly dries up the body and reduces secretions. In the case of total respiratory failure, patients are treated in the intensive care units with the help of a machine that helps them breathe properly. There is a limited number of these machines in the hospital and the patient might pass away in the case of all the machines being occupied. Besides, when the farmers experience slight symptoms of pesticide intoxication, they resort to nurses living in the same residential area, which results in misdiagnosing the cases properly due to nurses' lacking the adequate experience. In addition, there is a poor registration system in general, and registration only matters for patients. All highly toxic pesticides should be officially banned and the free availability is a serious issue."

Documents associated with pesticide intoxication were all reviewed in the Referral Hospital. The employee in the registration room reported that the ICD 10 system is the one that has been implemented for a long time now (more than 10 years) and to this present date. This system was implemented by the World Health Organization (WHO) in 1993 to replace ICD-9, which was developed by the WHO in the 1970s. ICD-10 is used in almost every country in the world, except the United States [52].

The employee also clarified that the registration system is not really efficient and the Ethiopian government will develop and start using its own system soon; however, only 56 cases of poisoning were officially registered in the past two years and labeled as poisoned due to unspecified drugs and biological substances. Therefore, data inserted in the system found to be not properly categorized, and the exact number of pesticide intoxication cases and intentional suicide trials among farmers and their families is unknown. This finding is in line with what the physician in the Referral Hospital declared about the poor registration system. However, the poor categorization of disease causals might be due to the registrars' lack of awareness about the importance of the accuracy of these numbers which are definitely a solid clue for the authorities to check the improvement of their performance.

The finding of this study regarding the registration of pesticide intoxication cases among farmers in Finchawa and Tullo rural kebeles found to be poor and in line with the study of [14] that was previously conducted.

4. Conclusion and recommendations

In conclusion, there is no gap of communication between farmers, and their authorities, as answers from both parties were perfectly matched. Statistically, the level of knowledge among the sample participants was found to be on average and was reflected in their field practices. However, while going into deeper details to address the presented and absent areas of knowledge among the participants, it was revealed that they were knowledgeable about the daily tasks that should be performed in the field, while the information about the effect of pesticides on the environment, on humans especially in the long-term, as well as the dermal route of exposure, were absent. Accordingly, the knowledge that farmers acquired from their experience, practices, field training and daily observations were insufficient to fill the hiatus of knowledge that is known to be obtained from the accumulation of information through education, and this was the gap that hindered farmers from mitigating their risk of exposure and had a joint significance on influencing the prevalence of pesticide intoxication among farmers and their families.

Therefore, knowledge-based training programs with practical classes and related courses are essential to improve farmers' level of knowledge about the adverse health effects of pesticides on human and environmental health, and help them address the simple protective methods to protect themselves and the environment around them. In addition, a specific budget should be dedicated by the government to provide farmers with adequate personal protective equipment to reduce their risk of exposure. Since the existence of highly toxic pesticides in farmers' residential area increased the risk of exposure among their family members, an official banning of highly toxic pesticides and replacing them with less toxic ones should be seriously considered. In the same respect, Pesticide application should be restricted to certified people who are trained, experienced and adequately equipped. Besides, improving the registration system in governmental hospitals is pivotal, and physicians should not prescribe any type of medication to their patients until they are registered and the disease is well categorized. Finally, construct hazardous waste collection units in Hawassa City for the proper disposal of empty chemical containers, rather than disposing of them in an inappropriate way.

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