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Research Article

Knowledge on Pesticide Handling Practices and Factors Affecting Adoption of Personal Protective Equipment: A Case of Farmers from Nepal

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Globally, the use of pesticide is growing day by day, but the use of PPE in developing countries is still low and farmers are directly exposed to chemicals which have negative health issues. Thus, this study was conducted in different places of Nepal where the use and adoption of chemical pesticide is high. This study aims on assessment of pesticide handling practices and determinants of adoption of PPE where 281 respondents were interviewed by the simple random sampling technique. A binary logit model was used to predict the determinants for adoption of PPE while spraying pesticides. Schooling years, training, reading label, and buying pesticide by name are the determining factors in adoption of PPE at 1% level of significance in the logit model. Still, the pesticide handling practices followed by farmers are not satisfactory and proper protective clothes are not used while spraying pesticides. Thus, to protect from different health issues, training, seminars, and talk discussion should be scheduled regarding safe pesticide handling practices and adoption of PPE. Also, the use of biopesticides should be encouraged as they are most promising and ecofriendly.

1. Introduction

World's 20–40% potential crop production is lost annually because of the effects of weeds, pests, and diseases [1]. In Nepal, postharvest and preharvest loss accounts for 15–25% every year [2]. Pesticides have proved to be beneficial in many ways from increasing food quality (size, color, and shape) and quantity, extending the storage life of food crops, and decreasing food prices. But, at the same time, pesticides can be extremely hazardous and have a detrimental impact on human health and other living organisms due to high toxicity [3]. Organophosphate insecticide and organochlorine are the commonly used pesticides in Nepal [2, 4] which inhibit the neurotransmitter acetylcholinesterase and affect the central and peripheral nervous system, also affecting the endocrine system which can lead to diabetes mellitus [5–8]. In Nepal, overuse and misuse of pesticides have resulted in a reduction of biodiversity and nitrogen fixation, changes in natural biological balances, ambient pollution in the environment, increasing pesticide resistance in some pests, and destruction of aquatic animals, birds, and other living organism's life. Thus, imprudent use of pesticides and other agricultural inputs has disrupted the ecological process of the agroecosystem, bringing farmers into the vicious cycle of increasing costs and reduced profits.

The national mean pesticide consumption of Nepal was 142 g/ha in the past years [2] which is now increased to 396 g/ha; however, a much higher rate (1600 g/ha) is used in commercial vegetable production such as in Sarlahi, Kavre, Tistung, Palung, Dhading, and some other districts of Terai area, which seems low compared to pesticide consumption of other Asian countries; however, the use of pesticides is not uniform in Nepal [9]. However, market-oriented production and agricultural intensification are leading farm workers to increase pesticide use at a rapid rate. There is also inappropriate and excessively toxic use of synthetic pesticides in some highly commercialized agriculture sectors [5], due to production objectives rather than health issues. Most pesticides are used in rice (40–50%), pulses (14–20%), cotton (13–15%), and vegetables and fruits (10–15%) [10]. The majority of the farmers are unaware of pesticide types, level of poisoning, safety precautions, and potential hazards on health and environment [5, 7, 8]. It has been estimated that the pesticide use pattern in Nepal is increasing by 10–20% every year [11]. The substantial increase in pesticide consumption is due to the dependency of agricultural crops and their productivity on synthetic pesticides [12].

Risks from pesticides are high because of the lack of knowledge of farmers, limited training and awareness on the safe production of food crops, the absence of an effective code of practices, and inadequate residue monitoring. Farmers' knowledge of the safe use of pesticides plays a crucial role in effective farm management. Improper handling and indiscriminate use of pesticides cause accidental poisoning and even acute or chronic health effects [13, 14]. In long run, pesticide exposure can cause long-lasting health issues such as dermatosis, cancer, and genotoxic, neurotoxic, and respiratory effects [3, 6, 13, 15]. In developing countries, the use of outdated, nonpatented, more toxic, and environmentally persistent pesticides are the leading causes of higher toxicity [9]. In the context of Nepal also, farmers do not always know about an active ingredient. Sometimes, outdated pesticides are sold to farmers. Farmers use a mixture of chemicals together; therefore, when incidents occur, it is difficult to specify the responsible chemical. Farmers' direct exposure occurs mainly through direct dermal contact with the pesticides and ingestion, which may happen during the preparation and application of the chemicals [16].

Protective clothes are not always available to farmers, and they are also not much aware about the use of it [16]. Personal protective equipment (PPE) designed to substantially reduce the risks associated with many hazardous farm activities is widely available [17].

Recently, various studies have focused on farmers' sociopsychological behavior, climate change, and impact of pesticide on human health [18,19]; however, to the best of our knowledge, no study has determined the knowledge on pesticide handling practices and factors affecting adoption of personal protective equipment in Nepal. Therefore, the current article focuses on the determinants of adoption of PPE while spraying pesticide and their knowledge in pesticide handling practices.

2. Research Methodology

2.1. Study Area. The study site was chosen from different places in Nepal where a similar type of research has not been conducted previously. The details of the study area (Figure 1) are shown in Table 1. The number of respondents varies from 5 to 60 [20].

2.2. Sample Size and Sampling Techniques. The sample size for the survey varies from 5 to 60 with a total of 281 respondents from 6 provinces of Nepal. Sampling techniques include simple random sampling without replacement where the study area was selected randomly and, thereof, also the respondents. A key informant interview was conducted with the use of semistructured questionnaires. Pilot testing was performed with 10 respondents of Morang but was not included in the datasets; it was mainly for the purpose of validity of questions and for including the farmers problem from the study area. The survey was conducted from February 19–March 15 (2020).

2.3. Research Questionnaire. The research questionnaire includes the questionnaires for primary information collection through interviews and focus group discussion (reliable to exchange knowledge and triangulate the collected information) [21]. Also, secondary information was used for supporting the findings of the study and was accessed through national and international open-access journals, newspapers, magazines, and bulletins.

2.4. Statistical Analysis. Data were entered into ms-excel 2013 and were analyzed using IBM SPSS V.21.0 and Stata 16. The details of the codings used in the data sheet are as shown in Table 2. The descriptive which includes frequency, percentage, mean, standard deviation, and chi-square association was analyzed using IBM SPSS V 21.0. However, for binary logit regression analysis, Stata (Stata-crop, LLC) was used [22].

Binary logit regression was used in this study to approach objectives. For the logit regression model [23], the dependent variable was the adoption of personal protective equipment whereas independent variables were gender, age, schooling years, number of members in the family, buying pesticide by names, reading labels, and training related to pesticide (Table 2). The logistic regression model was also used in [24] to determine the factors affecting safe pesticide handling. The model was also used in [22] to determine people's awareness of good agricultural practices and socioeconomic factors affecting them.

The likelihood (ratio) of the farmers for the adoption of PPE is determined by the odds ratio, i.e., the ratio of probability $Y = 1$ to $Y \neq 1$ (eq. (1)). However, the binary logit regression model is determined by the natural log of odds (eq. (2)). Furthermore, the logit regression model with respect to intercept, coefficients, and dependent and independent variables is shown as follows:

$$\text{Odds}(Y) = \frac{P(Y = 1)}{(1 - P)(Y \neq 1)}. \quad (1)$$

Applying natural log on both sides,

$$\ln \text{odds}(Y) = \ln\left[\frac{P(Y = 1)}{(1 - P)(Y \neq 1)}\right] = \text{logit}(Y). \quad (2)$$

Furthermore,

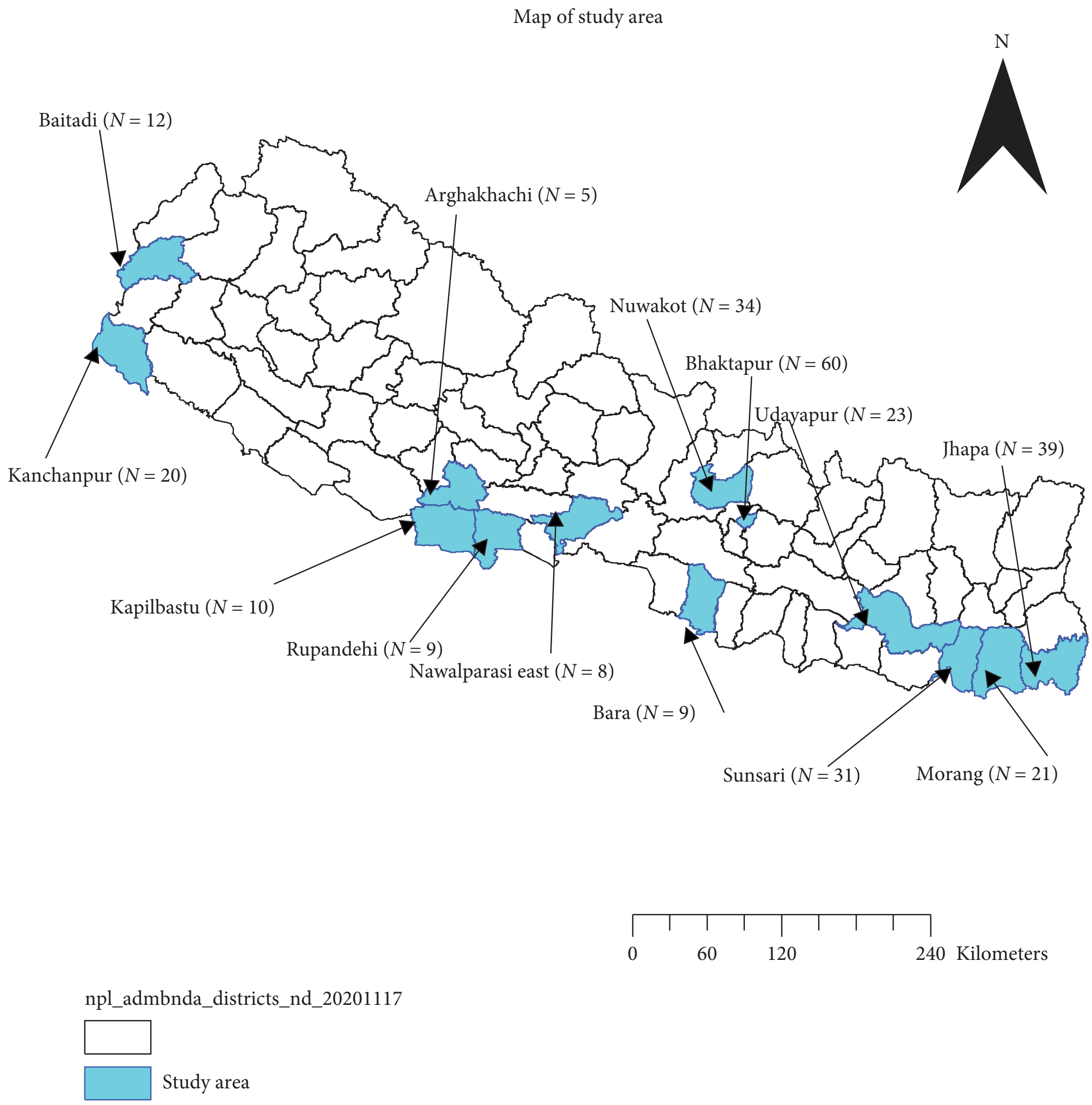

FIGURE 1: Map of Nepal with the study area.

TABLE 1: Description of the study area.

Provinces	Districts	Number of respondents interviewed
Province number 1	Morang	21
	Sunsari	31
	Jhapa	39
	Udayapur	23
Province number 2	Bara (Nijgadh)	9
Province number 3	Bhaktapur	60
	Nuwakot	34
Province number 4	Nawalparasi	8
Province number 5	Arghakhachi	5
	Kapilvastu	10
	Rupandehi	9
Province number 7	Kanchanpur	20
	Baitadi	12

$$\text{logit}(Y) = \alpha + \beta_1 X_1 + \beta_1 X_2, \ldots, \beta_n X_n + \varepsilon_0, \quad (3)$$

where Y = dependent variable (aware of using PPE or not), $X_1, X_2, \ldots, X_n$ = independent variable (age, gender, schooling years, family size, buying pesticide by name, reading labels, and training), β = coefficient of the independent variable, and ε_0 = error index.

3. Result and Discussion

3.1. Socioeconomic Characteristics. A total of 281 households were selected randomly from different places of Nepal, and the data were analyzed which indicate 40.6% females and 59.6% males, aged between 19–77 (39.52 ± 0.76). The higher number of males involved in farming has also been reported in [25–27]. Out of the total, 35.9% were found to be Brahmin, followed by 29.5% Chhetris, 2.8% Dalit, 25.3% Janajati, 3.6% Thakuri, and 2.8% others. The average family size of respondents was 5.29 (±0.108) with an average 2.17 (±0.060) economically active population. The literacy rate was 95% (primary: 22.4%, secondary: 28.8%, high school: 20.3%, and university; 23.5%), and 5% of people were found to be illiterate (Table 3). The involvement of respondents in

Table 2: Description of variables used in the binary logit model.

Variables	Type	Description	Value	Mean
Dependent variable				
Adoption of PPE	Dummy	Farmers are aware of using PPE or not	1 = aware 0 = unaware	0.73
Independent variable				
Gender	Dummy	Sex of the respondent	1 = male, 0 = female	0.59
Age	Continuous	Age of the respondent	Years	39.52
Number of members in the family	Continuous	Family size	Number of people living in a family	5.29
Land ownership	Dummy	Gender	1 = male, 0 = female	0.72
Schooling years	Continuous	Level of education	Years of schooling	9.85
Buying pesticide by name	Dummy	Buying respective pesticide by name or not	1 = buying pesticide by name, 0 = not	0.51
Reading labels	Dummy	Reading labels after buying or not	1 = reading labels, 0 = not reading labels	0.45
Training related to pesticide	Dummy	Attended training or not	1 = attended, 0 = not attended	0.21

agriculture as a primary occupation was 57.2% whereas a secondary occupation was 42.8%. Agriculture activity carried out by respondents on their land, on a lease, and on both was found to be 75.4%, 11.4%, and 13.2%, respectively. Land under farming varies from 0.1–8 ha. The main reason for fluctuation of land holding is due to the family-based farming system and land fragmentation [28].

Table 3: Socioeconomic characteristics of the study area.

Gender (%)	
Male	59.6
Female	40.4
Ethnicity (%)	
Brahmin	35.9
Chhetri	29.5
Janajati	25.3
Dalit	2.8
Thakuris	3.6
Others	2.8
Education (%)	
Primary	22.4
Secondary	28.8
High school	20.3
University	23.5
Illiterate	5.0
Age groups (%)	
Below 25	19.6
25–35	29.41
36–50	41.17
Above 50	9.8
Land ownership (%)	
Male	69
Female	31
Economically active population (mn ± SE)	2.17 ± 0.06
Average family size (mn ± SE)	5.29 ± 0.108
Land under farming (ha)	4.21 ± 0.328

Source: field survey, 2020.

3.2. Method of Pesticide Application and Handling Practices. Pesticide application includes seed treatment by fungicides, chemical methods for weed control, and spraying different chemicals to control insects, diseases, and pests in the crop field. Devices used for these purposes vary as per the size of the farm and the amount of pesticide needed. A majority of the farmers used knapsack sprayer (48.5%), broom (8.1%), hand sprayer (35.3%), and power sprayer (8.1%). During pesticide spraying, the direction of spraying and movement is considered to be important as it prevents direct contact from pesticide while spraying; 71.9% of the respondents considered the direction of wind while spraying, and 39.5% of them moved opposite to the direction of pesticide while spraying. The chi-square association was found to be dependent with training related to pesticide handling and agriculture, as shown in Table 4. For storing pesticide, 55.5% of respondents stored within the house, 10% did not consider the place for storage, 10.3% stored in a separate inventory, and 24.2% stored in the respective store made for storing chemicals and fertilizers. Bass et al. [29] reported that storing pesticide with houses rather than on separate inventory was most common. Sharma [4] reported the selling of harmful pesticides along with foods and also no proper knowledge on its handling, and it shows that still ignorance of handling of chemical pesticide persists [8]. Also, only 50.5% were found to buy pesticides by their respective names, and 45.2% were found to read the labels provided in pesticide bottles and sachets. Much care was not given regarding disposal of pesticides, 31.4% of the respondents do not know about disposal and 15% were found to throw in garbage bins, 20.8% were found to burn the bags and cans, and 32.8% were found to throw near the fields and in forests. Diomedi and Nauges [16] also reported that the majority of the respondents prefer to burn and bury the pesticides and packaging materials. The proper handling, storing, and disposing of chemical pesticide is necessary as it causes a harmful effect on humans, animals, livestock, and plants. The unusual disposing of pesticide leads to microbial population destruction and also the cause of pesticide flooding (accumulation of pesticides) in crops grown in the respective area, which makes them unsuitable for consumption [4].

Table 4: Chi-square association between handling of pesticide and training.

Parameters	Chi-square value	P value
Consider the direction of wind, training related to pesticide handling	6.492∗ ∗ ∗	0.011
Consider direction of wind, training related to agriculture	12.282∗ ∗ ∗	<0.001
Movement while spraying, training related to pesticide handling	6.151^{NS}	0.104
Movement while spraying, training related to agriculture	20.08∗ ∗ ∗	<0.001

∗ ∗ ∗ Highly significant at less than 1% level of significance.

3.3. Gender Role in Pesticide Handling. The division of labor in family-based farming practice is often common in developing countries such as Nepal. Mainly, females have less access to the market and have to involve in household and in-farm activities. In our study, males are dominant in buying pesticides (58%), followed by females (12.8%), and 29.2% responded that both males and females were involved in pesticide buying. Similar was the case with pesticide making where 40.2% of the males were involved in pesticide spraying followed by 20.6% females and 39.1% both of them. Similar was the case reported in [30] where males were dominant in pesticide handling (preparation and spraying). Women farmers make up the majority of total farming labor force in agriculture (10.8 versus 7.5 h/day) (FAO, 2000). The main reason for the involvement of males is due to the harmful effect of chemicals, and women are also less known to pesticide preparation which is to be carried out with care [25]. During pesticide spraying, a higher number of males were involved (41.6%), 18.9% were females and 39.5% were both males and females. A test of goodness of fit with the study area and pesticide buyers ($\chi^2 = 17.146$, P value = 0.076), pesticide makers ($\chi^2 = 35.815$, P value = 0.002), and spraying of pesticide ($\chi^2 = 21.923$, P value = 0.01) was significant (Table 5). The need for proper handling of pesticides is of utmost importance as pesticide residue is correlated to contamination in food and is detrimental to consumers' health [31].

3.4. Adoption of Personal Protective Equipment and Health Concern. Generally, Personal Protective Equipment (PPE) such as masks, gloves, boots, helmets, and long-sleeved clothes are found to be used as protective equipment during pesticide preparation and spraying [24, 32]. However, in our study, 73.3% were using personal protective equipment such as masks (34.9), masks and gloves (26.3), gloves (0.7%), and boots (0.7%), 14.8% used all of those for protection, and 26.4% of the respondents do not wear any personal protective equipment. The use of at least one protective equipment has been found in the majority of farmers [28]. The main reason for not wearing personal protective equipment was due to its unavailability in the study area (11.8%), not being aware of PPE (18.9%), and difficulty in working wearing PPE (8.9%). Farmers may not use safety measures if they have an economical burden or a time restraint to performing the work [33] or they are uncomfortable due to the heat stress and dampness experienced in the field [34]. Farmers do not know about safety gear required while spraying, the safe period required after spraying, and dosage.

After pesticide spraying, 60.9% of the respondents felt difficulty, 13.2% did not feel any difficulty, and 25.9% of the respondents were confused regarding health effects. Health effects recorded from the study are allergy on the skin, headache, difficulty in respiration, vomiting, and itching after pesticide spraying, which were similar to those reported in [14]. Zhang et al. [3] reported that due to pesticide use in fields, workers suffered from on-field pesticide poisoning in southern China and the health effects recorded were almost similar to our study, but much more serious health effects were also reported in [3]. Thus, lack of awareness in handling, spraying, and disposal and storage of pesticides could lead to adverse health effects in human beings [14]. Due to ignorance on safe handling of pesticide, directly the users and indirectly the nonusers are exposed to health effects; sometimes, the problem becomes more severe [6]. The use of goggles significantly reduced the eye irritation and masks reduced the incidence of nausea, vomiting, and dizziness. This shows that the use of PPE is still not satisfactory in the study area; farmers who are directly exposed to pesticide need to use goggles and masks to reduce the complications of health due to exposure.

Following the study in [6], the need for safety measures after pesticide spraying is necessary, and those practiced in the study area are washing hands and clothes with soap and water (31.3), washing hands and clothes with water (7.5%), washing hands with water only (8.2%), washing feet (0.7%), whole-body shower (33.8%), and washing hands only with soap and water (18.5%). Aryal et al. [6] reported that most of the respondents followed safety measures after spraying of pesticide, but very few were found to adopt a proper safety measures. The chi-square association between safety measures adopted and the use of personal protective equipment is significant ($\chi^2 = 26.271$, df = 5, P-value <0.001). After the pesticide application, safety measures need to be adopted, and washing hands, clothes, and taking bath are recommended [35].

The use of personal protective equipment was not found to be common among respondents during pesticide making and spraying. Thus, the logit model was used to determine the socioeconomic factors influencing the use of PPE. The LR chi-sq. (36.89) revealed that the independent variables have good explanatory power at 1% level of significance; i.e., socioeconomic factors jointly influence the adoption of PPE during pesticide spraying. The logit model estimated the pseudo R^2 0.115 which implies the variables included in the model explained 11.5% of the probability of the farm household's decisions whether to use PEE or not or the model fits at 11.5%. The logit regression model predicted that buying of pesticides, reading labels, years of schooling, and training related to pesticides were found to be significant (Table 6). The use of PPE is not found to be adopted by all the farmers in the study area and was found to be

Table 5: Gender role in pesticide handling in different study areas.

		Province number						Chi-sq. calc.	P value
		1	2	3	4	5	7		
Pesticide buyers	Male	58	4	60	0	20	21	17.146	0.076
	Female	11	1	15	0	3	6		
	Both	45	4	19	1	8	5		
Pesticide makers	Male	47	2	33	0	14	15	35.815	0.002
	Female	13	2	26	0	11	7		
	Both	56	5	35	1	5	8		
Spraying of pesticide	Male	45	5	36	0	16	15	21.923	0.01
	Female	12	1	25	0	10	5		
	Both	57	3	33	1	5	12		

Table 6: Factors influencing the awareness of the use of PPE.

Parameters	Coefficient	SE	Z	$P > z$	dy/dx
Gender	0.276258	0.3493992	0.08	0.937	0.046682
Age	0.0093598	0.0147979	0.63	0.527	0.0015816
Land ownership	0.4555738	0.35922354	1.27	0.205	0.0769828
Number of members in the family	0.386234	0.0824015	0.47	0.639	0.0065266
Schooling years	0.0781277∗	0.0390427	2.00	0.045	0.013202
Buying pesticide by name	0.9777317∗ ∗ ∗	0.322994	3.03	0.002	0.1652169
Reading labels	1.004339∗ ∗ ∗	0.3645625	2.75	0.006	0.1697131
Training related to pesticide	0.9218546∗	0.4811389	1.92	0.055	0.1557748
_cons	-0.6174914	0.9515647	-0.65	0.516	—

Log likelihood = −140.691, LR chi^2 = 36.89∗ ∗ ∗, pseudo R^2 = 0.115, ∗ ∗ ∗ significant at 1%, ∗ significant at 5%.

influenced by socioeconomic characteristics. The influence of socioeconomic characteristics on the adoption of equipment, new technology, and awareness has been reported in [22, 36, 37]. However, training was found to be an important determinant of the effective adoption of PPE [21]. Training jointly influences on the safe pesticide handling practices to both sellers and buyers [4, 7, 38].

From Table 6, it can be concluded that one unit increase in years of schooling increases the probability of adoption of PPE use by 1.32%. Similarly, a unit increase in buying of pesticide by name increases the use of PPE by 16.5%, and reading labels make people aware of using PPE by 16.9%. The number of respondents who were found to have taken training related to pesticide is increased by one unit; then, the use of PPE was influenced by 15%. Furthermore, a unit increase in land ownership by males and then adoption of PPE was influenced by 7.6%. The association of adoption of PPE with socioeconomic characteristics such as education, farming experience, and institutional service was determined. Though the use of PPE is influenced by socioeconomic characteristics, an unsatisfactory result was obtained regarding pesticide handling and use of PPE [38]. Sapbamrer and Thammachai [39] reported that significant determinants associated with PPE use are demographic factors (i.e., education/literacy level, experience of illness, and income); farm structure factors (i.e., farm size); behavioral and psychosocial factors (i.e., contact with pesticides, perceptions, attitudes, awareness, norms, and beliefs); and environmental factors (i.e., information about pesticides, access to extension services, training program, and farm organization).

3.5. Need for Pesticide Uses. In agriculture, pesticides are generally chemical compounds used to manage and control different diseases, insect infestation, and weeds. Farmers have highlighted the importance/need of pesticides as they help to increase food productivity, help in the increase of net return/profit, and also help to produce more with less land use. Pesticides are also useful to prevent rats, mice, and other insects from contaminating food while they are being stored [40]. Also, the use of pesticide is increasing day by day and is termed as pesticide trade mill due to mass consumption of pesticide [40].

From this study, we have found 4% of the population uses pesticide for storage need, 1.8% for seed treatment, 58.7% for crop protection, and the remaining 39.1% for all the abovementioned needs. Here, 61.9% of people use pesticide for the control of diseases and insects, 2.5% for the control of weeds, and the other 35.6% for all-crop protection, seed treatment, and storage bins. Sapkota et al. [32] reported that most of them used pesticides to control diseases and for seed treatment. However, they were not much found to use pesticides in storing grains.

3.6. Training and Knowledge on IPM. In this study, we have found out 21.4% have attended training related to pesticide use and its handling practices. The major portion of the population is still devoted to their heritage knowledge and ancestral practices. Since IPM is an alternative to pesticides which is used only when necessarily required for effective results and long-term control, still only 33.1% knew IPM but were following it quite partially. After getting complete knowledge in IPM, there was a significant reduction in the use of chemical pesticides in the cotton belt of Punjab, Pakistan [41]. Thus, IPM is a promising method on pest management to be adopted as it has no or less toxic effect and not exposed to health issues [6]. This indicates the dominance of the chemicals on the field and less aware of implementing IPM techniques as a promising methodology [28, 32]. The information/ideas on/about pesticides gained were 1.8%, 8.5%, and 48.2% from agrovets, extension officers, and NGOs/INGOs, respectively. Likewise, about 39.0% of the population was found to have acquired knowledge from all the abovementioned sources. Also, their guidance and suggestions were found to be quite effective and valuable for the management of pests and diseases with the use of chemicals. Rijal et al. and Sapkota et al. [28, 32] also reported that agrovets were the primary source of information for pesticide selection which is contrasting to our finding where the majority of respondents gained information from NGOs/INGOs. Similarly, the increase in adoption was found to be influenced by extension services and other related services provided by government agencies [21].

4. Conclusions and Policy Implications

Pesticide handling practices in the study area were not satisfactory, and different health issues were reported. The logit regression model used to identify the factors determining people's awareness on the use and adoption of PPE was found to fit with 11.5% of data, and sociodemographic factors such as years of schooling, reading labels, buying pesticides by name, and training related to pesticide handling were found to be the influencing factors for the use of PPE. Thus, more attention is to be given on creating awareness for the adoption of PPE and training on pesticide handling to both the retailers and buyers. Extension services should be increased so that peoples are likely to have more awareness.

For the safe pesticide handling and adoption of PPE, the following policy measures are suggested:

(i) Farmers and agrochemical traders should be given training (formal and informal) for safe pesticide handling and adoption of PPE to undermine occupational health exposure.

(ii) Pesticide should be used in a proper formulations and should be disposed in safer zones.

(iii) Use of biochemicals and biopesticides should be encouraged rather than synthetic chemicals. Biochemicals and biopesticides are promising to sustainable farming.

(iv) The IPM method should be adopted, and IPM-FFS (Integrated Pest Management-Farmers Field School) should be promoted.

(v) Persistant organic pollutants and illegal pesticides should be banned.

Data Availability

The data used on this research will be made available on request after publication.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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