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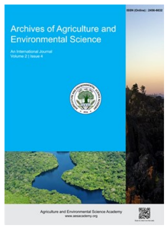

ORIGINAL RESEARCH ARTICLE

CrossMark

Factors affecting the knowledge of vegetable farmers of Chitwan and Makwanpur district over pesticide use

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ABSTRACT

A study was conducted in two districts of Nepal to determine the factors influencing the knowledge of vegetable farmers regarding pesticide use. The use of pesticides in agriculture is considered necessary but can pose significant risks if handled inadequately or impractically. The study collected data from 136 vegetable growers, with 68 farmers from each district, and also involved 5 agro vets from both districts using random sampling techniques. The findings indicated that only 13.23% of the farmers were found to wear full personal protective equipment (PPE), while 83.08% used partial PPE, and 3.67% applied pesticides without any protective gear. This finding was statistically significant at the 10% level. Among the different types of protective gear, masks were the most commonly used by the farmers. The majority of farmers (62.5%) reported being poisoned during pesticide mixing and spraying, with eye irritation being the most frequently reported symptom. Farm households that underwent training in pesticide usage and vegetable cultivation experienced a statistical enhancement of 20.6% in their knowledge. Moreover, farmers who were educated, had access to extension services, had long experience in pesticide usage, or had a history of poisoning in their farm household witnessed corresponding improvements of 9%, 18%, 2.1%, and 9.3% in their knowledge of pesticide use. The study urges agricultural organizations to implement training, promote literacy, offer extension services, and raise awareness to enhance farmers' knowledge and safety, contributing to sustainable agriculture and farmer well-being.

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INTRODUCTION

Pesticides are an essential element of contemporary agriculture, playing a critical function in preserving elevated levels of agricultural productivity. As a result, intensive agricultural production systems that require high-input and widespread pesticide use to manage pests have become a prevalent feature (Tilman *et al.*, 2002). Nonetheless, the overuse of pesticides raises significant environmental and health issues. Poor handling and excessive application of pesticides lead to the destruction of non-targeted species and soil, water, and air contamination (Jallow *et al.*, 2017). The exposure of farm workers to pesticides has been linked to adverse health effects such as cancer and birth defects, causing hundreds of fatalities, most of which occur in developing countries (Litchfield, 2005; FAO, 2014). Several scientists contend that the inordinate and inappropriate application of pesticides, especially in developing nations, is associated with insufficient education and training in pesticide usage, absence of substitutes to pesticides, inadequate awareness concerning related hazards, stringent market demands for flawless crop appearance, and farmers' unwillingness to assume the risk of crop damage (Wilson and Tisdell, 2001; Damalas and Hashemi, 2011; Khan *et al.*, 2015). Improved levels of education can provide farmers with better access to information about pesticides and greater knowledge of the appropriate number of pesticides to utilize (Shetty *et al.*, 2010). Conversely, farmers with less education may encounter difficulties in accessing information about pesticides and complying with recommended safety and application guidelines (Matthews, 2008).

Some experts claim that excessive use of pesticides is an inevitable outcome of the feeble implementation of pesticide laws and regulations, national policies that offer incentives for pesticide application, and aggressive advertising by agrochemical corporations and their middlemen (Marcoux and Urpelainen, 2011; Schreinemachers and Tipraqsa, 2012). Additionally, other factors such as social and farm characteristics, absence of access to extension support, and farmers' attitudes toward pesticide risk are also considered to be major determinants of farmers' conduct concerning pesticide overuse. For instance, farmers with low levels of pesticide risk perception are more disposed to overuse pesticides as compared to those with heightened risk perception (Dasgupta *et al.*, 2007; Hashemi and Damalas, 2010; Hashemi *et al.*, 2012; Liu and Huang, 2013).

Fernandez, (2019) reported that Nepal is placed at the 103rd rank with a pesticide consumption of 0.2 kg/ha. The country's average pesticide consumption stands at 369g a.i./ha, which is higher than the previous record (PQPMC, 2018). In terms of pesticide use, Japan ranks first among Asian countries with 10.8 a.i. kg/ha, while China leads in annual pesticide consumption (Sharma *et al.*, 2019). Nepal imported a total of 635 tons of pesticide in the FY 2018/2019, with 169 tons of insecticide, 347 tons of pesticide, 105 tons of weedicide, and 14 percent of others. Pesticide use is more prevalent in the terai ecological belt, accounting for 59% of total pesticide consumption in Nepal, with a pesticide use of 0.995 a.i. kg/ha (PQPMC, 2019). Farmers possess knowledge regarding the unfavorable impact of pesticide utilization, yet they neglect to adopt precautionary measures, thus resulting in an increased risk of exposure to pesticide intoxication. Multiple studies have demonstrated that farmers tend to disregard instruction labels during application and lack a proper area for pesticide disposal (Aryal *et al.*, 2016). Additionally, the majority of farmers do not utilize Personal Protective Equipment (PPE) while applying pesticides (Jallow *et al.*, 2017).

It is of utmost importance to evaluate the factors contributing to the knowledge acquisition regarding the use of chemical pesticides in agriculture, given the mounting evidence that these pesticides can pose a significant threat to human health. Despite the growing body of literature documenting the harmful effects of pesticide use in Nepal, only a handful of studies have been conducted to pinpoint the root causes behind the misuse and overuse of these chemicals, as exemplified in the research conducted by AlZadjali *et al.*, (2014). The present study aims to address this gap in the literature by pursuing two main objectives: first, to assess the extent of use of protective gear and second, to identify the primary drivers of knowledge regarding pesticide use. Comprehending the conduct of farmers regarding pesticide usage and identifying the determinants that prompt them to excessively employ pesticides would offer significant insights that could aid in formulating educational and policy suggestions aimed at curtailing pesticide utilization. Additionally, this knowledge plays a vital role in furthering agricultural sustainability and mitigating the deleterious impact of pesticides on human well-being and the ecosystem.

MATERIALS AND METHODS

Selection of the study area and sample size

Chitwan and Makwanpur districts of Nepal were chosen. In the study sites, 10 local agro-vets 5 from each district were selected randomly for this study. Chitwan district and Makwanpur spread across an area of 2,238.39 km² and 2,426 km² (CBS, 2011). A good survey sample should have both a small sampling error and a minimum standard error (Casley and Kumar, 1988; Kinnear and Taylor, 1987). A sample size of 60 is generally regarded as the minimum requirement for a larger population that yields a sufficient level of certainty for decision-making (Poate and Daplyn, 1993). Altogether 136 vegetable farmers were selected randomly for the survey-68 growers each from Chitwan and 68 from Makwanpur. A list of farmers involved in vegetable farming was obtained from governmental institutions (AKC, Vegetable zone) and a sampling random technique was used. The primary data were collected through a household survey from May to March 2020.

Methods of data analysis

Chi-square test was used to compare the categorical socioeconomic variables of two district. Additionally, the Tobit model was used to measure the intensity of knowledge (McDonald and Moffit, 1980; Kristajanson *et al.*, 2005; James *et al.*, 2006). This model was chosen because it has an advantage over other analytical models in that, it reveals the intensity of knowledge (Maddala, 1992; Johnston and Dandiro, 1997). In such cases, the Tobit model, which has both discrete and continuous parts, is appropriate. The Tobit model is a censored normal regression model. Its estimation is related to the estimation of a censored. The function is estimated from a censored sample where the sample population consists of both farmers from the Chitwan and Makwanpur districts. Let Y be the knowledge of the farmers, Y* is equal to an index reflecting the combined effect of the explanatory variables affecting the intensity of knowledge regarding the use of pesticides, Y* is not observable and is recorded as zero for not having any knowledge and 1 for having the higher level of knowledge. The empirical Tobit model is expressed as:

$Y = X_\beta + \mu_i$ if $X_\beta > \mu_i$, 0 if $X_\beta = \mu_i$ (1)

$Y = Y^*$, if $Y^* > 0$

$= 0$ if $Y^* \le 0$

Where,

X = vector of the explanatory variable

β = vector of the Tobit maximum likelihood estimates

μ = random error term (independently distributed with mean 0 and variance)

Table 1. Variables used in the Tobit model.

Variable	Description	Unit
Age	Age of household head	Years
Family type	Type of family	1=Nuclear and 0=Otherwise
Education status	Education level of the household head	No. of years of education
Access to loan	Whether the farmers had access to loans or not	1=Yes and 0=Otherwise
Years of pesticide use	No. of years farmers using pesticide	Years
Vegetable farming experience	No. of years farmers are involved in vegetable cultivation	Years
Training received	Whether farmers have received training	1=Yes and 0=Otherwise
Family membership in an organization	Whether the farmers belong to any group or no	1=Yes and 0=Otherwise
Extension visits	Frequency of Extension worker visit	1=Yes and 0=Otherwise
Poisoned	Poisoning experience	1=Yes and 0=Otherwise

To examine the knowledge of vegetable farmers regarding pesticide use is specified as a function of socioeconomic and institutional factors as follows:

$Y = \beta_0 + \beta_1 Age + \beta_2 Family\ type + \beta_3\ Education\ status\ of\ HH + \beta_4\ Access\ to\ loan + \beta_5\ Years\ of\ pesticide\ use + \beta_6\ Training\ received + \beta_7\ Vegetable\ farming\ experience + \beta_8\ Family\ membership\ of\ organization + \beta_9\ Extension\ visit + \beta_{10}\ Status\ of\ poisoned + \mu_i$

Where Y=Range of vegetable farmer's knowledge level over pesticide use, β_0 = constant and μ_i = the random error term.

RESULTS AND DISCUSSION

Socio-demographic characteristics

The study revealed men predominantly served as household heads (81.2%). Among the farmers, 55.15% were illiterate, while 44.85% had literacy skills, and this difference was statistically significant at a 1% level (Table 2). Interestingly, only 36.8% of families were joint households, while 63.2% were nuclear households. This contradicts the national average of 17.1% for nuclear families reported by CBS, (2021). Regarding pesticide handling training, only 30.88% of farmers had received training, while 69.11% had not, and this difference was statistically significant at a 5% level. These findings align with a similar study conducted by Rijal *et al.* (2018), indicating a lack of training as a primary cause for the communication gap between extension workers and farmers regarding pesticide use. Furthermore, the study found that 88.2% of households identified agriculture as their primary employment, surpassing the national average of 65.2% reported by CBS (2021). Other employment sectors included business, government, and civil service.

Full and partial personal protection equipment use

The study revealed that only 13.23% of farmers used full Personal Protective Equipment (PPE), while 83.08% used partial PPE (which is any or combination of the following: cap/hat, glove, goggle, boot, mask, long sleeve, and overall). Notably, 3.67% of farmers applied pesticides without any protective gear, and this difference was statistically significant at a 10% level. Among the partial PPE users, 91.18% used masks, 62.50% used gloves, 60.29% used long-sleeved clothing, 25.0% used spectacles, 19.12% used hats, and 19.85% used shoes (Table 3). In comparison to other studies, the findings differ. Shrestha *et al.* (2010) reported that 66.6% of farmers did not use any personal protective measures due to knowledge and affordability issues. Thapa *et al.* (2021) found that 73.3% of respondents used various personal protective equipment, with masks being the most common (34.9%), followed by masks and gloves (26.3%). However, 26.4% of respondents did not use any personal protective equipment. Similarly, Bhandari *et al.* (2018) observed that a significant proportion of farmers did not use specific protective gear, such as hats, long-sleeved shirts and pants, gloves, and masks, mainly due to unawareness, unavailability, and discomfort. Interestingly, in our study, more farmers were observed using masks, gloves, long-sleeved shirts and pants, and other protective gear during pesticide application. This could be attributed to increased awareness and availability of such equipment in the study area.

Status of pesticide poisoning

A significant majority of farmers (62.5%) reported experiencing pesticide poisoning during the process of mixing and spraying, resulting in various health problems such as headache, eye irritation, and skin diseases. Similar studies conducted by Kafle *et al.* (2021) found that 18.7% of farmers experienced acute symptoms related to pesticide exposure within the past 12 months. In our study, among the population affected by pesticide poisoning, 54.4% reported experiencing headaches, 60.1% reported eye irritation, 37.5% reported itching problems, 34.6% reported weakness, 5.9% reported vomiting, 5.1% reported stomach pain, and 1.5% reported unconsciousness (Table 4). These findings align with Bhandari *et al.* (2018), who reported that the most frequently self-reported symptoms related to pesticide toxicity were headache (73.8%), skin irritation (62.3%), eye irritation (32.8%), weakness (22.4%), and muscle pain (19.1%).

Another study by Gurung (2019) also found that respondents experienced symptoms such as headaches (23%) and nausea, as well as skin problems like itching, rashes, burns, and allergies (25%), which are consistent with the findings from our study.

Table 2. Socio-demographic characteristics categorical variable.

Variable	Percentage difference between the two districts			
	Chitwan (n=68)	Makwanpur (n=68)	Overall (N=136)	Chi-square value
Gender Household head				
Male	50(73.53)	61(89.71)	111(81.6)	
Female	18(26.47)	7(10.29)	25(18.4)	5.930**
Literacy of Household head:				
Literate	22(32.35)	53(77.94)	61(44.85)	
Illiterate	46(67.64)	15(22.05)	75(55.14)	28.567***
Training received				
Yes	53(77.94)	41(60.29)	42(30.88)	
No	15(22.05)	27(39.70)	94(69.11)	4.960**
Family type				
Nuclear	41(60.29)	41(60.29)	86(63.2)	
Joint	27(39.71)	27(39.71)	50(36.8)	0.001
Occupation				
Agriculture	63(92.65)	57(83.82)	120(88.2)	
Non-Agriculture	5(7.35)	11(16.18)	16(11.75)	2.550

Note: Figures in the parentheses indicate percentages. ***, **, and * indicate 1%, 5%, and 10% levels of significance, respectively (Source: Field Survey, 2020).

Table 3. Full and partial personal protection equipment used in the study area .

Variable	Chitwan (n=68)	Makwanpur (n=68)	Overall (N=136)	Chi-square value
Full PPE	5(7.69)	13(19.11)	18(13.23)	
Partial PPE	59(86.76)	54(79.41)	113(83.08)	3.710* (p=0.054 at 1df)
No PPE	4(5.80)	1(1.47)	5(3.67)	

Note: Figures in the parentheses indicate percentage. * Indicates 10% level of significance. Source: (Field survey, 2020)

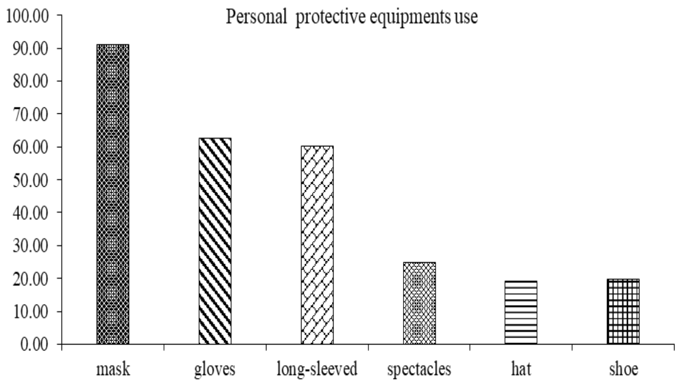

Figure 1. *Different Personal Protective Equipment's used in study area.*

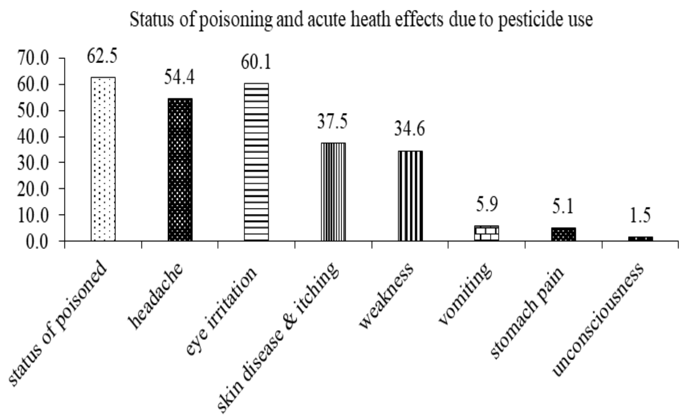

Figure 2. *Status of poisoning and acute health effects due to pesticide use.*

Different factors affecting the knowledge of vegetable farmers regarding pesticides use

The study found several factors that influence farmers' knowledge of pesticide use. These factors include age, training received, educational status, years of pesticide usage, access to extension workers, and previous poisoning incidents. Among these variables, training, educational status, years of pesticide usage, access to extension workers, and previous poisoning were statistically significant (Table 5). Similar studies by Memon *et al.* (2019) and Wang *et al.* (2017) have also shown a positive correlation between knowledge of Personal Protective Equipment (PPE) and advancing age. Although our findings align with this, the association was not statistically significant. Farm households that received training in pesticide usage and vegetable growing had a significant improvement of 20.6% in knowledge. The investigation carried out by Moradhaseli *et al.* (2017) ascertained that instruction about pesticides had a favorable impact on the utilization of Personal Protective Equipment (PPE) and the implementation of pesticide safety procedures, a finding that aligns with our research. Higher levels of literacy were associated with a 9% increase in farmers' knowledge of pesticide use, which was statistically significant (Table 5). The investigations conducted by Memon *et al.* (2019); Taghdisi *et al.* (2019); Mequanint *et al.* (2019) have demonstrated comparable discoveries. Consequently, it can be deduced that individuals

Table 4. Status of pesticide poisoning in the study area.

Variable	Chitwan (n=68)	Makwanpur (n=68)	Overall (N=136)	Chi-square value
Status of pesticide poisoning:				
Yes	42(61.70)	43(63.23)	85(62.5)	0.031** (p = 0.859 at 1df)
No	26(38.20)	25(36.76)	51(37.5)	

Note: Figures in the parentheses indicate percentages. ** Indicates 5% level of significance, (Source: Field survey, 2020).

Table 5. Factors affecting the knowledge level over pesticide use.

Variable	Marginal effect(dy/dx)	Coefficient	Standard error	p-value
Age	0.010	0.001	0.002	0.511
Training received	0.206***	0.366	0.037	0.000
Family type	-0.035	-0.036	-0.042	0.389
Education status	0.090**	0.005	0.005	0.041
Frequency of pesticide application	0.012	0.390	0.391	0.023
Year of pesticide use	0.021*	0.003	0.003	0.091
Vegetable farming experience	0.016	0.016	0.017	0.337
Family membership in an organization	0.023	0.240	0.042	0.570
Extension worker access	0.180*	0.041	0.021	0.056
Poisoned status	0.093**	0.094	0.037	0.011
Observations	136			
Log-likelihood	33.955			
Pseudo R^2	-2.4464			
Prob > chi	0.000			

Note: ***, ** and * indicate 1%, 5% and 10% levels of significance, respectively (Source: Field Survey, 2020).

who lack literacy skills in farming or have limited educational qualifications are at greater risk when handling pesticides. The inability to comprehend the guidelines on safe handling and the hazardous effects of pesticides may explain the aforementioned higher risk among this group (Taghdisi *et al*., 2019). Each additional year of pesticide usage was associated with a 2.1% increase in knowledge of safe pesticide behavior, which was statistically significant at 10%. These findings are in concurrence with those previously reported by Sharifzadeh *et al.* (2019), wherein a favorable correlation was observed between the exposure to health risks associated with the handling of pesticides (B = 0.128, P < 0.01) and regular health check-ups (B = 0.166, P < 0.01). The occurrence of health-related problems may have resulted in both direct and indirect costs for farmers in the past, and hence they may endeavor to avoid such expenses in the future (Sharifzadeh *et al*., 2019). Access to extension services increased the likelihood of knowledge improvement by 18%, a statistically significant finding at 10%. Sharifzadeh *et al.* (2017); Wang *et al.* (2017) have similarly observed the positive influence of government and market-provided information on pesticide safety practices. If a farm household member has previously been poisoned, there is a 9.3 % chance that their degree of knowledge will improve which is statistically significant at 5% (Table 5). Farming experience also showed a positive correlation with a 1.9% increase in knowledge about safe pesticide use. Nonetheless, the relationship between farm experience and PPE usage lacks clarity, as suggested by Memon *et al.* (2019). Membership in organizations increased the odds of knowledge improvement by 2.3%. Damalas *et al*., (2019) found that farmers who emulated their colleagues' behavior within organizations were more likely to exhibit safe pesticide practices. The frequency of pesticide application was positively correlated with a 9% increase in knowledge of proper safety behavior. Okonya *et al.* (2019) also observed a positive correlation between pesticide application frequency and PPE utilization as farmers may have real-time experience with more pesticide spraying.

Conclusion

This investigation aimed to assess the factors influencing vegetable farmers' knowledge of pesticide use. It was observed that a significant number of farmers practiced inadequate handling and usage of pesticides and protective equipment, posing risks to their health, agriculture, and the environment. Insufficient use of complete protective gear resulted in cases of poisoning during pesticide spraying, leading to symptoms such as headache, itching, vomiting, weakness, and eye irritation. Limited access to extension services was identified as a contributing factor to improper pesticide use in the study area. However, the availability of training programs, instances of pesticide poisoning, and farmers' educational levels were found to increase awareness about safe pesticide practices. It is essential to prioritize the accessibility and affordability of protective equipment, provide comprehensive training and extension services, and enforce regulations related to pesticide use to promote responsible pesticide use, enhance productivity, and ensure the well-being of farmers.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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