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Drivers of Personal Safety in Agriculture: A Case Study with Pesticide Operators

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Abstract: Agriculture is a hazardous occupational industry for farmers and farm workers; therefore, decisions to improve safety in the working place require understanding behavior of farmers and farm workers and factors affecting it. This study examined factors influencing perceived importance of personal safety and safe behavior of farmers in terms of personal protective equipment (PPE) use in pesticide spraying. Data were collected from a previous survey of farmers in rural areas of northern Greece. Over half of the farmers (55.4%) perceived low importance of personal safety in pesticide spraying. Perceived importance of personal safety increased in young farmers, with high education level, and large land area as well as with high perception of risk, knowledge of pesticide toxicity, seminar in pesticide use, access to internet, and perceived usefulness of PPE. Most farmers showed unsafe behavior in PPE use in terms of using long-sleeved shirt, long pants, chemical resistant gloves, socks, and shoes (58.9%). Farmers perceived low risk of pesticides (65.2%), despite the fact that two out of three farmers (66.1%) perceived high usefulness of PPE. Safe behavior in pesticide use increased in young farmers, with high education level, and small land area as well as with high perception of risk, knowledge of pesticide toxicity, seminar in pesticide use, access to internet, and perceived usefulness of PPE. Binary logistic regression analysis showed that knowledge of pesticide toxicity, education, age, and farm size were significant predictors of perceived importance of personal safety. In addition, self-confidence in spraying, following colleagues' behaviors, risk perception, knowledge of pesticide toxicity, and farm size were significant predictors of safe behavior in terms of PPE use during pesticide spraying. Findings highlight differences in how farmers perceive personal safety and how they finally respond in daily action with respect to personal safety measures. Perception of risk, knowledge of pesticide toxicity, and farm size were common significant predictors for both variables. Lifelong education targeting promotion of knowledge about pesticide risks among farmers should be always a priority.

Keywords: Binary logistic regression; farmers; health; insecticides; perceptions; protection; toxicity

1. Introduction

Farming is one of the most dangerous occupations [1]. Agriculture and forestry consistently rank as the third or fourth most hazardous occupation in the European Union. People who work on farms, including farm owners, workers, and their families as well as rental workers, are exposed to life-threatening dangers five times more than other work forces [1]. Chemical fertilizers and plant protection products are important means of increasing productivity of agricultural systems. However, unsafe use of these chemicals poses risks to those involved in farming activities. The potential of chemicals to cause harm builds upon a number of factors, including how dangerous the chemicals are as well as how long and how often people are exposed to them.

The issue of safety is one of the most important challenges faced by employers and workers in agriculture. Therefore, safety in farming needs active management, like any other aspect of farm production. Safety measures can minimize health risk and prevent injuries. Maintaining and developing human resources in the risky agricultural environment requires learning and observing safety principles and agricultural hygiene. In particular, the wide use of chemicals and fertilizers can cause health disorders in this sector (e.g., eye irritation, skin burns, respiratory problems, asthma, headaches, seizures, and loss of consciousness) [2,3]. Therefore, practical measures to prevent accidents and ill health are essential for promoting safety in farming. From this point of view, farmers and farm workers must make safety their first priority, as this is the only way to reduce risks of farm accidents that can harm their health. However, in countries with serious economic constraints, interventions for reduction of pesticide exposure should not rely solely on promotion of personal protective equipment (PPE) use; other strategies requiring less worker input, such as elimination and substitution of highly hazardous pesticides and improving application methods, might be suitable [4]. To achieve sustainable development in agriculture, the health status of farmers and farm workers along with related factors should be monitored. However, the first step to protect farmers' and farm workers' health against workplace hazards is the recognition of hazards that threaten farmers' and farm workers' health.

Previous research on farmers' and farm workers' behaviors revealed crucial factors affecting safety in the use of pesticides. Self-efficacy and risk perception among dairy farmers, who were pesticide applicators in Wisconsin, USA, appeared less relevant to safety behavior than other variables [5]. In Malaysia, factors that significantly prevented occurrence of acute symptoms in male farmers after pesticide application were the good sprayer condition, the habit of no smoking during pesticide application, and the habit of changing clothes immediately after spraying [6]. Although most Latino farm workers in the US adhered to approved laundry procedures for working clothes, the number of farm workers in the household was negatively associated with devotion to suggested behaviors in terms of hygiene practices [7]. Evidently, farm workers must be trained by employers to engage in safety behavior that will secure their personal safety [8]. Previous training on pesticide use was related with high knowledge of pesticides among farmers and lower levels of pesticide exposure [9]. In addition, knowledge on occupational safety practices positively influenced farmers' use of safe practices [10]. Previous research showed that pesticide exposure knowledge was strongly related to perceived risk [11]. Training programs on safe handling practices, including long-term hazards of pesticides on health and the environment, can promote safety among farmers and pesticide retailers [12,13]. However, the decision of farmers to use PPE was personal and influenced little by outside parties [14]. In Australia, non-use of PPE was reported among cereal farmers; up to 40% of the farmers commonly used no PPE at all during pesticide handling [15]. In the same study, PPE use was mainly associated with young farmers. This finding indicates that improved knowledge is not enough to change farmers' behavior to work in a safe way. Therefore, interactive and participatory training is required to bridge the gap between knowledge and practice needs [16]. Moreover, women working in small-scale agriculture in rural KwaZulu-Natal, South Africa, had limited access to pesticide training and followed few safety practices when mixing and spraying pesticides [17]. Therefore, gender-sensitive educational programs should be implemented to increase the awareness of safety amongst farmers [18]. Grzywacz et al. [19] identified the source of behavior change resulting from a health education intervention focused on pesticide safety (La Familia Sana) to immigrant Latino families. The intervention produced changes in three sets of pesticide safety behaviors, i.e., appropriateness of the conceptual targets or theoretical levers for behavior change, basic capacities of the intervention audience, and attributes of the intervention vehicle [19]. In North Carolina, USA, farm workers recognized pesticide protective behaviors as helping them to not get sick and perceived work experience as facilitating protective behaviors [20]. Nowadays, transitioning concerns about farmers' health into preventative action remains a challenge for agricultural health professionals [21].

Proper interventions to minimize health problems of farmers in the working environment require the identification of factors that contribute to unsafe behavior. However, changing hazardous behaviors of farmers requires changes in knowledge and attitudes. Studies show that farmers consider themselves as healthy as long as they can carry out their work [22,23]. Therefore, farmers tend to ignore health issues that could have serious long-term consequences. Identifying and prioritizing issues and problems of farmers in observing the safety and health tips in agriculture are of major importance. Analysis of the factors influencing farmers' behavior in different areas of health and safety is essential [24]. However, research on farmers' behavior in pesticide use is relatively limited in the literature. The present study explored factors influencing perceived importance of personal safety and behavior of farmers in terms of PPE use in pesticide spraying. The findings are supposed to illuminate crucial factors influencing both importance of personal safety and safe behavior of farmers in terms of PPE use in pesticide spraying.

2. Materials and Methods

2.1. Study Area and Sample Selection

The study used 112 randomly selected farmers from a previous survey [25] in rural areas of northern Greece (Figure 1). Farmers were randomly selected, based on the fact that they were involved in agriculture and particularly in pesticide spraying. Two-stage cluster sampling with small subsets was used to collect data. First, clusters (municipalities) were purposively selected to serve the objective of the study and then from those selected clusters, farmers were randomly selected from random sub-samples (villages). For this purpose, we asked for assistance of the leaders of farmers' groups, so that active farmers who were helpful and likely to point the real status, according to the objective of the study, were interviewed independently. Farmers heard a brief description of the project and its objective and then gave oral consent to participate in the project. The study was for academic research, so that no personal data were kept. In total, 112 interviews were fully completed. Participants were mainly involved in the cultivation of cereal grains, cotton, and tobacco.

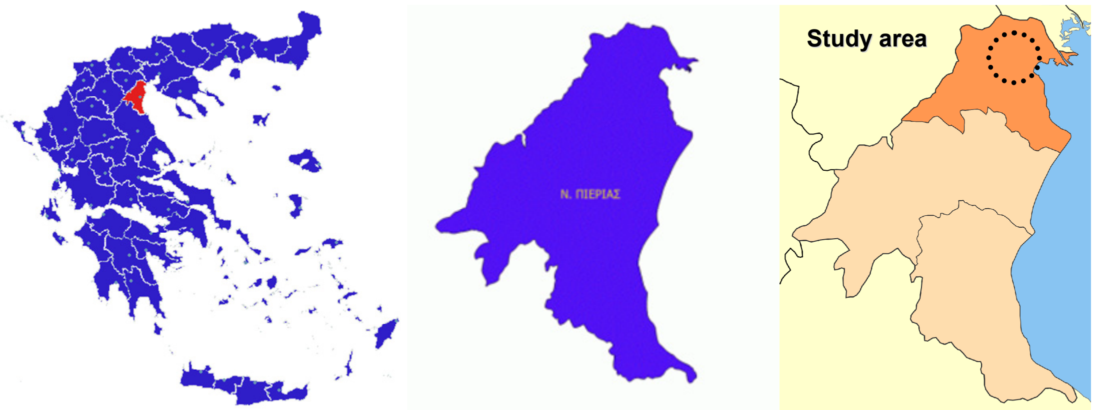

Figure 1. Diagrammatic sketch showing map of Greece and the location of the study site.

2.2. Questionnaire and Data Collection

This study examined factors influencing perceived importance of personal safety and behavior of farmers in terms of PPE use in pesticide spraying. Perceived importance of personal safety was assessed on a 3-point scale (0 = do not know, low = 1, and high = 2). Farmers' behavior in terms of PPE use was measured collecting information about various PPE items each farmer commonly uses when spraying pesticides, using a 5-point scale (ranging from 1 = never to 5 = almost always). Moreover, background information, such as age (years), education (years), farming experience (years), marital status (no, yes), perception of risk from pesticides (no, yes), knowledge of pesticide toxicity (no, yes), seminar on pesticide application (no, yes), access to internet (no, yes), self-confidence in spraying (no, yes), perceived usefulness of PPE like face mask and goggles (no, yes), and following colleague farmers' behavior (no, yes) was collected. The above variables were selected from a review of the existing literature [26–30] and took into account the local farming conditions of the study area (i.e., climate, cropping patterns, and general social and economic conditions). It should be noted, however, that a single question is not a good measure of risk perception, self-efficacy, or a set of behaviors. This is a weakness of the current study, but we mainly used dichotomous questions that are simple to understand, easy in data collection, and do not allow ambivalent answers [31]. Despite the fact that the dichotomous questions fail to capture any intensity of feeling, the aim was to cover a large number of variables as independent variables for predicting importance of personal safety and safe behavior of farmers.

2.3. Data Analysis

Data were inspected with the statistical package for social sciences (SPSS). Summary statistics were used to describe the collected data. Farmers were divided to those who perceived high importance of personal safety and those who perceived low (or no) importance of personal safety. According to common standards [32], the use of a long-sleeved shirt, long pants, chemical resistant gloves, socks, and shoes was considered as the minimum requirements for characterizing farmers' behavior as safe during pesticide spraying. Technically, these work clothes items are not considered PPE but are required on most pesticide labels. Therefore, farmers who used those items in pesticide handling were considered to show safe behavior, while the remaining farmers were considered to show unsafe behavior. Associations of potential risk factors for importance of personal safety and safe behavior for each control group were assessed with Chi-square tests for dichotomized variables and independent sample t-tests for continuous variables. Binary logistic regression was used to check significant factors influencing farmers' importance of personal safety and farmers' safe behavior during pesticide handling. Binary logistic regression is commonly used when the dependent variables are dichotomous (i.e., only take two values). This method can describe the relationship between a binary dependent variable than can be continuous or discrete and several independent variables. One regression was run for importance of personal safety as dependent variable and one regression was run for safe behavior as dependent variable. Unless otherwise stated, differences of means were declared significant at $p < 0.05$.

3. Results

3.1. Farmers' Characteristics

Mean age of the respondents was 44.14 years, with a considerable part (32.1%) being over 50 years (Table 1). Most respondents (41.1%) had education above 12 years, with an average education level of 9.18 years, indicating a relatively educated sample of farmers. Most farmers (83.0%) were married, while farmers appeared almost divided in terms of access to internet (55.4% reported no access to internet). The average land size under farming was 12.37 ha, with most respondents (42.9%) found in the category of 6 to 10 ha. With reference to other characteristics of the sample (Table 2), few farmers (24.1%) had a seminar on pesticide application, while most farmers (65.2%) perceived no risk of pesticides. Additionally, three quarters of the farmers (75.0%) were unaware of the toxicity of the pesticides they were using, but most farmers reported high self-confidence in spraying (88.4%). Two thirds of the farmers (66.1%) perceived high usefulness of PPE (like face mask and goggles), while few (8.9%) reported following colleagues' behavior. Concerning safe behavior in pesticide handling, most farmers (58.9%) did not show safe behavior (Figure 2). Similarly, most farmers (55.4%) did not consider personal safety important (Figure 2).

Table 1. Farmers' basic characteristics.

Variable	Frequency	Percentage
Age (mean = 44.14, SD = 13.36)		
Less than 30 years	26	23.2
From 31 to 40 years	16	14.3
From 41 to 50 years	34	30.4
More than 50 years	36	32.1
Education (mean = 9.18, SD = 3.50)		
Less than 6 years	45	40.2
From 6 to 11 years	21	18.7
More than 12 years	46	41.1
Land size (ha) (mean = 12.37, SD = 7.35)		
Less than 5 ha	16	14.3
From 6 to 10 ha	48	42.9
From 11 to 15 ha	13	11.6
From 16 to 20 ha	16	14.3
More than 21 ha	19	16.9
Marital status		
No	19	17.0
Yes	93	83.0

SD: standard deviation.

Table 2. Other characteristics of farmers.

Variable	Frequency	Percentage
Access to internet		
No	62	55.4
Yes	50	44.6
Seminar on pesticide application		
No	85	75.9
Yes	27	24.1
Risk perception		
No	73	65.2
Yes	39	34.8
Knowledge of pesticide toxicity		
No	84	75.0
Yes	28	25.0
Self-confidence in spraying		
No	13	11.6
Yes	99	88.4
Perceived usefulness of PPE		
No	38	33.9
Yes	74	66.1
Following colleagues' behavior		
No	102	91.1
Yes	10	8.9

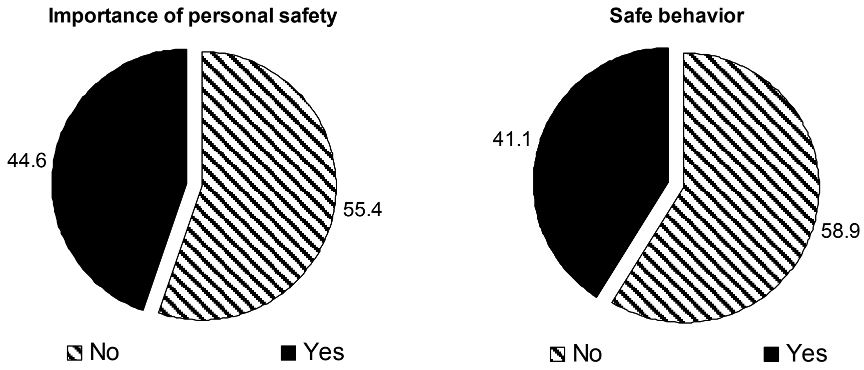

Figure 2. Farmers' importance of personal safety and safe behavior.

3.2. *Perceived Importance of Personal Safety and Safe Behavior*

Perceived importance of personal safety increased in young farmers ($t = 7.08$, df = 110, $p < 0.01$), with high education level ($t = 10.17$, df = 110, $p < 0.01$), and with large land area ($t = -5.43$, df = 110, $p < 0.01$) (Figure 3). Safe behavior increased in young farmers ($t = 6.72$, df = 110, $p < 0.01$), with high education ($t = -8.84$, df = 110, $p < 0.01$), but decreased with small land area ($t = 4.03$, df = 110, $p < 0.01$) (Figure 3).

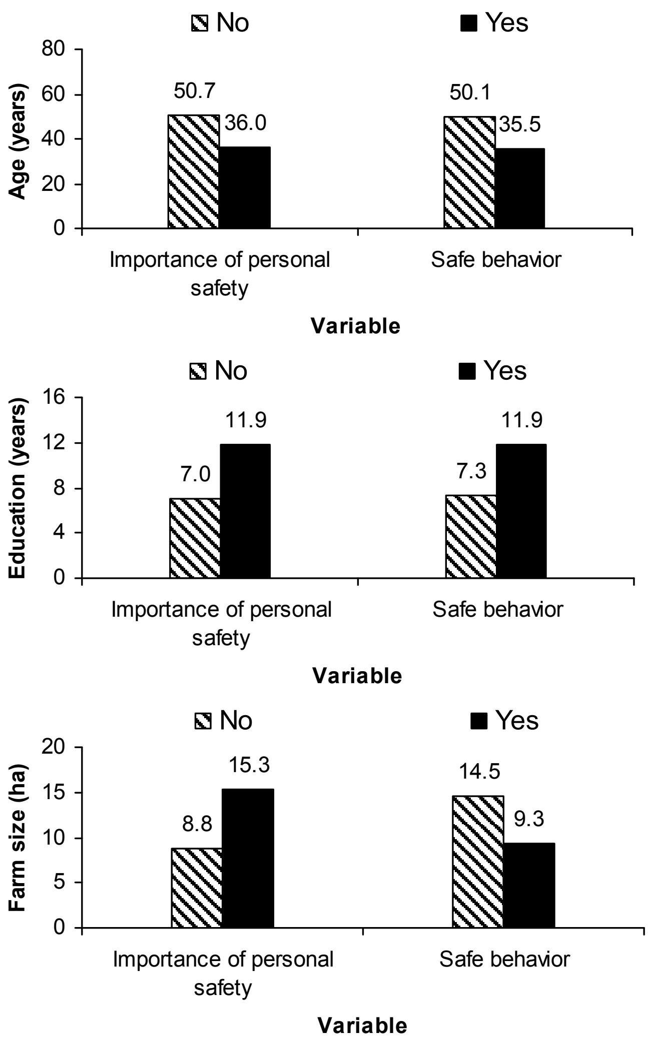

Figure 3. Importance of personal safety and safe behavior as affected by farmers' demographic variables (t-test results).

Importance of personal safety in pesticide use increased with high risk perception, knowledge of pesticide toxicity, seminar on pesticide use, in single farmers, access to internet, and perceived usefulness of PPE ($p < 0.01$, chi-square test) (Table 3). Safe behavior in pesticide use increased with high risk perception, knowledge of pesticide toxicity, seminar on pesticide use, access to internet, and perceived usefulness of PPE ($p < 0.01$, chi-square test). It should be noted that importance of personal safety and safe behavior increased in both single and married farmers, but the effect of marital status was significant only for importance of personal safety (Table 3).

Table 3. Importance of personal safety and safe behavior as affected by farmers' variables (Chi-square test results).

Variable	Frequency	Importance of Personal Safety		Safe Behavior	
		No	**Yes**	**No**	**Yes**
Risk perception	No	55	7	64	2
	Yes	18	32	9	37
		$\chi^2 = 33.88$, $p = 0.000$		$\chi^2 = 71.56$, $p = 0.000$	
Knowledge of pesticide toxicity	No	58	4	63	3
	Yes	26	24	21	25
		$\chi^2 = 25.48$, $p = 0.000$		$\chi^2 = 35.86$, $p = 0.000$	
Seminar on pesticide application	No	62	0	66	0
	Yes	23	27	19	27
		$\chi^2 = 44.12$, $p = 0.000$		$\chi^2 = 51.05$, $p = 0.000$	
Marital status	No	6	56	8	58
	Yes	13	37	11	35
		$\chi^2 = 5.24$, $p = 0.022$		$\chi^2 = 2.67$, $p = 0.102$	
Access to internet	No	47	15	49	17
	Yes	15	35	13	33
		$\chi^2 = 23.50$, $p = 0.000$		$\chi^2 = 23.19$, $p = 0.000$	
Self-confidence in spraying	No	6	56	8	58
	Yes	7	43	5	41
		$\chi^2 = 0.51$, $p = 0.478$		$\chi^2 = 0.041$, $p = 0.839$	
Perceived usefulness of PPE	No	31	31	29	37
	Yes	7	43	9	37
		$\chi^2 = 16.01$, $p = 0.000$		$\chi^2 = 7.18$, $p = 0.007$	
Following colleagues' behavior	No	56	6	61	5
	Yes	46	6	41	5
		$\chi^2 = 0.13$, $p = 0.721$		$\chi^2 = 0.36$, $p = 0.545$	

3.3. Binary Regression

With reference to importance of personal safety in pesticide use, the log-likelihood value (44.96) and the Hosmer-Lemeshov goodness-of-fit test value (12.42) showed adequate fit of the model (Table 4). The model is highly persuasive, with an overall predictive accuracy of 92.2%. The high value of Nagelkerke R^2 probably reflects the suitability of the independent variables in the model, as these variables are common determinants of farmers' perceptions of personal safety when using pesticides as reported in the literature [25–27]. Binary logistic regression showed that age, education, knowledge of pesticide toxicity, and farm size were significant predictors of this variable (Table 4). Risk perception was marginally non-significant ($p = 0.05$), while age showed a negative association with importance of personal safety in pesticide use, indicating that old farmers perceived less importance of personal safety in pesticide use. With reference to safe behavior, the log-likelihood value (30.54) and the Hosmer-Lemeshov goodness-of-fit test value (0.72) showed adequate fit of the model (Table 5). The model is highly persuasive, with an overall predictive accuracy of 95.5%. As noted above, the high value of Nagelkerke R^2 probable reflects the suitability of the independent variables in the model, as these variables are common determinants of farmers' safety behavior when using pesticides as reported in the literature [25–27]. Binary logistic regression showed that risk perception, knowledge of pesticide toxicity, farm size, self-confidence in spraying, and following colleagues' behaviors were significant predictors of this variable in terms of PPE use during pesticide spraying (Table 5). All independent variables showed a positive association with safe behavior in pesticide use. Concerning both variables (importance of personal safety and safe behavior), three variables were common predictors, i.e., risk perception, knowledge of pesticide toxicity, and farm size (Tables 3 and 4). Moreover, while age and education were significant predictors of importance of personal safety, this was not the case for safe behavior. For the latter, self-confidence in spraying and following colleagues' behaviors were additional significant predictors. It should be noted that, due to the small sample size (112 cases for each model), both models could be considered potentially overfitted (and optimistic), which might reduce their generalizability outside the original dataset. It would have been desirable to have more participants to take possible overfitting into account, but this would have required including participants from a larger area and diverse cropping patterns, which would add additional exogenous variables. Therefore, we only included 112 farmers who were involved in pesticide spraying and were sufficiently familiar with the safety environment during pesticide handling. In this regard, the models fully reflect the real status of farmers' behavior in pesticide handling in the study area.

Table 4. Binary regression analysis for importance of personal safety.

Variable	B	S.E.	Wald	Sig.	Exp(B)
Risk perception	2.669	1.360	3.853	0.050	14.431
Age (years)	−0.127	0.046	7.635	0.006	0.881
Education (years)	0.882	0.249	12.572	0.000	2.416
Knowledge of pesticide toxicity	2.928	1.304	5.044	0.025	18.685
Seminar on pesticide application	24.475	5796	0.000	0.997	4.26E+10
Farm size (ha)	0.218	0.110	3.947	0.047	1.244
Marital status	1.291	1.564	0.681	0.409	3.636
Access to internet	1.935	1.500	1.665	0.197	6.925
Self-confidence in spraying	−0.570	1.383	0.170	0.680	0.565
Perceived usefulness of PPE	0.935	1.203	0.605	0.437	2.548
Following colleagues' behaviors	0.611	1.533	0.159	0.691	1.841
Constant	−12.765	5.221	5.979	0.014	

−2 Log likelihood = 44.96; Hosmer and Lemeshov test (χ^2 = 12.42, df = 8, p = 0.13); Pseudo R-squares (Cox and Snell R^2 = 62.2%; Nagelkerke R^2 = 83.3%); Overall percentage of correctly predicted = 92.2%; B: unstandardized regression weight; S.E.: standard error; Sig.: significance; Exp(B): exponentiation of the B coefficient.

Table 5. Binary regression analysis for safe behavior.

Variable	B	S.E.	Wald	Sig.	Exp(B)
Risk perception	4.855	1.741	7.780	0.005	128.365
Age (years)	−0.144	0.090	2.589	0.108	0.866
Education (year)	0.388	0.240	2.610	0.106	1.473
Knowledge of pesticide toxicity	4.370	1.984	4.850	0.028	79.058
Seminar on pesticide application	24.623	4797	0.000	0.996	4.939E+10
Farm size	0.430	0.215	3.990	0.046	1.537
Marital status	−2.604	2.142	1.478	0.224	0.074
Access to internet	−0.245	2.392	0.011	0.918	0.782
Self-confidence in spraying	8.803	3.456	6.487	0.011	6655
Perceived usefulness of PPE	0.043	1.549	0.001	0.978	1.044
Following colleagues' behaviors	6.182	2.886	4.589	0.032	483.723
Constant	−13.189	7.039	3.511	0.061	

−2 Log likelihood = 30.54; Hosmer and Lemeshov test (χ^2 = 0.72, df = 8, p = 0.98); Pseudo R-squares (Cox and Snell R^2 = 66.1%; Nagelkerke R^2 = 89.1%); Overall percentage of correctly predicted = 95.5%; B: unstandardized regression weight; S.E.: standard error; Sig.: significance; Exp(B): exponentiation of the B coefficient.

4. Discussion

The present study explored factors influencing perceived importance of personal safety and behavior of farmers in terms of PPE use in pesticide spraying. Research on farmers' behavior in pesticide use is relatively limited in the literature, particularly regarding PPE use and, therefore, findings of this study are essential for better understanding and improving the safety level of pesticide use. Most farmers showed unsafe behavior in PPE use (58.9%). Farmers perceived low risk of pesticides (65.2%), despite the fact that two-thirds of the farmers (66.1%) perceived high usefulness of PPE. Binary logistic regression analysis showed that knowledge of pesticide toxicity, education, age, and farm size were significant predictors of perceived importance of personal safety. However, self-confidence in spraying, following colleagues' behaviors, risk perception, knowledge of pesticide toxicity, and farm size were significant predictors of safe behavior in terms of PPE use during pesticide spraying. Although trends identified in the current study corroborate most findings of previous research, findings highlight differences in how farmers perceive personal safety and how they finally respond in daily action with respect to personal safety measures. Concerning both studied variables (importance of personal safety and safe behavior), three farmers' variables were common predictors, i.e., risk perception, knowledge of pesticide toxicity, and farm size. This means that both perceived importance of personal safety and safe behavior increased with high perception of risk about pesticides, high knowledge levels of pesticide toxicity, and large area under farming. Moreover, self-confidence in spraying and following colleagues' behaviors were additional significant predictors of safe behavior.

Risk perception has been reported to affect safe behaviors of farmers when dealing with pesticides. Usually, farmers show low risk perception of the impact of pesticide use on public health and environmental integrity [33]. For several farmers and farm workers, a general belief that exposure to pesticides is unavoidable for those working with pesticides, limits implementation of safety measures in using and storing pesticides [34]. Previous research showed that young growers perceived higher levels of risk by the harmful impact of pesticides on health than elderly growers and thus behaved more safely than old growers [35]. However, in Pakistan, a clear tendency toward pesticide overuse was found, irrespective of age, but the probability decreased in IPM-trained farmers, educated farmers, and farmers who used highly toxic pesticides [36]. Jin et al. [37] found that pesticide overuse decreased with farmers' risk perceptions, while Wang et al. [38] mentioned an indirect effect of knowledge on farmers' perceptions of pesticide risk, which eventually promoted safe pesticide practices. Evidently, education and training efforts can play a major role in risk perception related to pesticide safety. Therefore, including risk-perception studies in the development of educative and risk-communication efforts would be beneficial, bridging research to action [39].

Knowledge of pesticide hazards has been linked with great impact of farmers' attitudes on behavior. Farmers' knowledge of pesticide risks was positively related with attitudes towards pesticide use [29]. As confirmed in the present study, knowledge of pesticide toxicity was associated with increased safety behavior. This trend fully agrees with findings of a previous study, where awareness of pesticides high toxic potential tended to discourage overuse [36]. On the other hand, poor understanding of pesticide hazards among inhabitants and farm workers has been reported to imply high exposure potential to organochlorine pesticides [40]. Moreover, low competence in proper handling practices, farmers' reliance on pesticides, and limited opportunities to pesticide training were linked with high pesticide exposure risk levels [41]. Typically, knowledge of health risks by pesticide use is boosted with training and, therefore, improving farmers' knowledge of pesticide use must be of first concern for limiting farmers' exposure to pesticides [9]. It should be noted that although awareness of pesticide harmful effects was related to less poisoning by pesticides [42], high knowledge of pesticide hazards did not always associate with adequate safety measures [43]. This information highlights that high knowledge levels of pesticide hazards alone are not sufficient to change farmers' behavior towards safety. Therefore, the existing disparity between knowledge and daily safety practice of farmers must be eliminated by participatory training [16], such as problem-solving discussion (where learning derives principally from the participants themselves rather than from an instructor), role play (where trainees are presented with a situation which they are required to explore by acting out the roles of those represented in the situation) or field demonstration (where a dynamic environment near to or within the scenes of real action is provided for learners to be a part of).

Self-confidence in spraying was found to be a significant predictor of safe behavior. Farmers' self-confidence (here used as synonymous of self-efficacy) refers to the belief in themselves through their abilities to achieve personal goals [44]. Based on the findings of the present study, the role of self-efficacy in spraying has been confirmed as an important component in reducing farmers' risky behaviors. Self-confidence makes farmers to understand and develop ability to face risks, intensifying their efforts and, if necessary, trying to change the work environment [45]. In this regard, it was found that safe practices in pesticide use were likely to be adopted with increased self-efficacy in the safe practice [46]. Moreover, high self-efficacy in safety positively impacted farmers' implementation of safety practices [10]. Hence, it appears that self-efficacy could predict farmers' behaviors in pesticide use. People with high self-efficacy show elevated confidence in their skills and have no doubt about themselves [47]. In these cases, farmers consider the problems as a challenge, not a threat, and they actively search for new situations. In addition, high self-efficacy reduces fear of failure, increases the level of motivation, and improves problem-solving and analytical thinking abilities. In the same way, high self-efficacy in spraying may promote the use of PPE.

Following colleagues' behaviors in spraying was found to be a significant predictor of safe behavior. People often ignore their own opinion when making a decision in favor of the opinions of others. This response arises by the desire of people to gain approval by conforming to expectations of others. In this sense, people often make decisions that are consistent with their social environment. Following other people's behaviors captures people's perception of social pressures to perform or not to perform a specific behavior [48]. It is reasonable to assume that an individual under social influence will try to conform to the expectations of others [49]. This response could be because subjective norms may be seen as an extrinsic motivational fact that can encourage farmers to self-regulate the use of pesticides, namely, farmers would be more likely to behave in a way that is regarded desirable by others.

Overall, findings of this study could enable national authorities to make better-informed decisions aimed at minimizing health hazards associated with pesticides at farmers' level. For example, the information collected in this study could be used for the design of appropriate knowledge-based training programs for farmers that are supported by field demonstrations. However, because training farmers may fail to reduce pesticides risks, training activities should be regular and systematic for consolidating results. Moreover, interventions that provide farmers with knowledge of pesticide safety should be complemented with other strategies. In this regard, training pesticide retailers to increase their knowledge of pesticide safety and risk communication is also critical. The current study used a random sample from the target population to which the results of the study could be generalized. Although significant trends found in this study may be valid in several similar settings, the generalizability of research findings to populations in other settings is unknown and results should be interpreted with caution.

5. Conclusions

This study provides practical information for grasping vital factors affecting perceived importance of personal safety and safe behavior of farmers dealing with pesticide use. Several farmers' variables, such as knowledge of pesticide toxicity, education, age, and farm size, were identified as significant predictors of perceived importance of personal safety. In addition, self-confidence in spraying, following colleagues' behaviors, risk perception, knowledge of pesticide toxicity, and farm size were found to be significant predictors of safe behavior in terms of PPE use during pesticide spraying. Findings highlight differences in how farmers perceive personal safety and how they finally respond in daily action with respect to personal safety measures, with perception of risk, knowledge of pesticide toxicity, and farm size being common significant factors for both variables. Lifelong education enhancing knowledge about pesticides should be targeted. Training and extension services are also essential.

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