

Original Research Article

Knowledge and expressed practices regarding pesticide handling among farmers in rural Himachal Pradesh, India: a cross-sectional study

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ABSTRACT

Background: Pesticide use is integral to modern agriculture but poses significant occupational health risks, particularly in developing countries where unsafe handling practices are common. Farmers in rural India are frequently exposed to pesticides due to inadequate knowledge, poor safety practices, and limited training. Objectives were to assess the knowledge and expressed practices regarding pesticide handling among farmers in selected rural areas of Himachal Pradesh and to determine the relationship between knowledge and practices.

Methods: A descriptive cross-sectional study was conducted among 100 farmers using pesticides in rural areas of district Una, Himachal Pradesh. Participants were selected using purposive sampling. Data were collected through a structured interview schedule assessing knowledge and a structured rating scale assessing expressed practices. Descriptive and inferential statistics were applied, including Karl Pearson's correlation coefficient and Chi-square test.

Results: Most farmers demonstrated moderate knowledge regarding pesticide handling, while unsafe practices were prevalent. A positive correlation was observed between knowledge and expressed practices ($p < 0.05$). Knowledge levels were significantly associated with educational status and pesticide-related training.

Conclusions: Despite moderate awareness, unsafe pesticide handling practices remain common among farmers. Targeted training programmes, improved access to safety information, and promotion of personal protective equipment are essential to reduce pesticide-related health risks.

Keywords: Farmers, Himachal Pradesh, Knowledge, Occupational health, Pesticide handling, Practices

INTRODUCTION

Agriculture remains the backbone of the Indian economy, employing nearly 55% of the country's workforce and contributing substantially to food security, rural livelihoods, and national economic growth.¹ India ranks among the world's leading producers of milk, pulses, spices, fruits, vegetables, cotton, sugarcane, and fish, supported by the second-largest agricultural land area globally.² However, the intensification of agricultural practices to meet growing food demands has led to a marked increase in the use of chemical fertilizers and

pesticides, particularly in developing countries like India.³

Pesticides are chemical or biological agents used to prevent, destroy, or control pests that threaten agricultural productivity. These include insecticides, herbicides, fungicides, rodenticides, and nematocides, each differing in chemical composition, mode of action, and toxicity profiles.⁴ While pesticides play a critical role in minimizing crop losses and enhancing yield, their indiscriminate and unsafe use has emerged as a significant public health and environmental concern.⁵

Globally, pesticide consumption has increased steadily over the past few decades. According to FAOSTAT, agricultural pesticide use reached approximately 3.73 million tons of active ingredients worldwide in 2023, reflecting a 14% increase over the past decade.⁶ Developing countries account for a substantial proportion of this increase due to expanding agricultural activity, limited regulatory enforcement, and inadequate farmer education.⁷ Despite representing a smaller share of global pesticide consumption compared to high-income countries, low- and middle-income nations bear a disproportionately higher burden of pesticide-related morbidity and mortality.⁸

Human exposure to pesticides occurs through multiple routes, including inhalation during spraying, dermal contact, ingestion of contaminated food and water, and accidental or intentional poisoning.⁹ Acute exposure may result in symptoms such as headache, dizziness, nausea, vomiting, respiratory distress, and skin irritation, while chronic exposure has been associated with serious long-term health outcomes, including cancers, neurological disorders, endocrine disruption, reproductive dysfunction, and metabolic diseases.¹⁰⁻¹² The World Health Organization estimates that approximately 385 million cases of unintentional pesticide poisoning occur annually worldwide, leading to nearly 11,000 deaths.¹³

Agricultural workers are among the most vulnerable populations due to frequent and prolonged exposure to pesticides, often in the absence of adequate safety measures.¹⁴ Unsafe practices such as mixing pesticides with bare hands, spraying without personal protective equipment (PPE), re-entering treated fields prematurely, improper disposal of containers, and unsafe storage within households significantly increase exposure risks.¹⁵ In many rural areas, pesticides are commonly stored inside homes, making them easily accessible to children and other family members, thereby increasing the risk of accidental poisoning and self-harm.¹⁶

In India, pesticide regulation is overseen by the Central Insecticides Board and Registration Committee (CIBRC), which approves pesticide formulations and specifies recommended uses.¹⁷ However, enforcement gaps, poor awareness of regulatory guidelines, and reliance on pesticide retailers for information often lead to inappropriate pesticide selection and misuse.¹⁸ Older, highly hazardous pesticides some banned or restricted in developed countries continue to be used in Indian agriculture due to their low cost and easy availability.¹⁹

Several studies conducted across India have documented inadequate knowledge and unsafe pesticide handling practices among farmers. Research from northern and southern regions of the country indicates that a large proportion of farmers do not read pesticide labels, lack awareness of toxicity levels, and fail to use PPE consistently.²⁰⁻²³ Even when farmers possess basic knowledge of pesticide hazards, this awareness frequently

does not translate into safe practices, highlighting a critical gap between knowledge and behavior.²⁴

Himachal Pradesh, a predominantly agrarian hill state, presents unique challenges related to pesticide use. Agriculture provides direct employment to nearly 70% of the state's working population, with terrace farming being the dominant practice due to the state's mountainous terrain.²⁵ The region's diverse agro-climatic conditions favour the cultivation of cereals, vegetables, and high-value horticultural crops, necessitating frequent pesticide application to control pests and diseases.²⁶ Increased dependence on pesticides in recent years has raised concerns regarding occupational exposure, environmental contamination, and food safety in the region.²⁷

Despite government initiatives such as the PM Programme for Restoration, Awareness Generation, Nourishment and Amelioration of Mother Earth (PM-PRANAM), which promotes reduced chemical fertilizer use and sustainable agricultural alternatives, pesticide safety remains inadequately addressed at the grassroots level.²⁸ Limited access to formal training, low literacy levels among some farming communities, and insufficient agricultural extension services further exacerbate unsafe pesticide handling practices.²⁹

Evidence from Himachal Pradesh and neighboring states indicates a rising burden of pesticide-related health problems. According to the National Crime Records Bureau, accidental pesticide poisoning accounted for a significant proportion of poisoning-related deaths in northern Indian states, including Himachal Pradesh.³⁰ Many such incidents are preventable through proper storage, safe handling, and timely education of farmers.

Understanding farmers' knowledge and day-to-day practices regarding pesticide handling is essential for designing effective intervention strategies. Knowledge influences risk perception, while practices determine actual exposure levels. The health belief model suggests that perceived susceptibility, perceived severity, perceived benefits, and perceived barriers collectively shape health-related behaviors.³¹

Aim

A cross-sectional study to assess the knowledge and expressed practices regarding pesticide handling among farmers in selected areas of Himachal Pradesh.

Objectives of the study

To assess the knowledge regarding pesticide handling among farmers in selected areas of Himachal Pradesh. To assess the expressed practices regarding pesticide handling among farmers in selected areas of Himachal Pradesh. To find a correlation between the knowledge and practices regarding pesticide handling among farmers in selected areas of Himachal Pradesh. To find the

association of knowledge with selected demographic variables, i.e. age, gender, educational status, years of farming experience, and training related to pesticide handling among farmers in selected areas of Himachal Pradesh.

METHODS

Study design

A descriptive cross-sectional study was conducted to assess the knowledge and expressed practices regarding pesticide handling among farmers in selected rural areas of Himachal Pradesh, India.

Study setting

The study was carried out in selected rural villages under the jurisdiction of Tira, Raipur, and Mandli Gram Panchayats of district Una, Himachal Pradesh. Una district was chosen due to its predominantly agrarian population, extensive pesticide uses in cereal and vegetable farming, and feasibility of data collection. Agriculture is a major source of livelihood in this region, and pesticide use is common due to pest prevalence and crop protection demands.

Study population

The study population comprised farmers who were actively involved in pesticide use for agricultural purposes in the selected rural areas. For this study, a farmer was defined as an individual who stores, prepares, applies, or disposes of pesticides during farming activities.

Sample size and sampling technique

The required sample size for an indefinite population was calculated using the Raosoft sample size calculator, yielding a minimum recommended sample of 384 participants. However, due to practical constraints such as difficult terrain, weather conditions, limited transportation, and time limitations, a final sample size of 100 farmers was selected for the present study.

A non-probability purposive sampling technique was used to recruit participants who met the inclusion criteria. This method was selected to ensure that participants had direct experience with pesticide handling and could provide relevant information aligned with the study objectives.

Inclusion criteria

Farmers who used pesticides for agricultural activities. Farmers willing to participate in the study. Farmers who understood Hindi. Farmers available at the time of data collection.

Exclusion criteria

Farmers exclusively engaged in organic farming. Farmers unwilling to participate or exhibiting non-cooperative behaviour.

Data collection instruments

Data were collected using two structured tools developed by the investigator after an extensive review of relevant literature and national program guidelines:

Tool I: structured interview schedule for knowledge assessment

This tool consisted of 28 multiple-choice questions designed to assess farmers' knowledge regarding: Basic concepts of pesticides, safe purchase, storage, and disposal, use of personal protective equipment (PPE), health hazards of pesticide exposure, first aid measures in pesticide poisoning

Each correct response was awarded one mark, and incorrect responses were scored zero. The total possible score ranged from 0 to 28. Knowledge levels were categorized as: poor knowledge: <50% (0-13), moderate knowledge: 50-75% (14-20), good knowledge: >75% (21-28).

Tool II: structured rating scale for expressed practices

A 5-point structured rating scale comprising 20 statements was used to assess expressed practices related to pesticide handling, including storage, preparation, application, disposal, and use of PPE. Responses were recorded as always, often, sometimes, rarely, or never.

Both positively and negatively worded items were included to minimize response bias. Scores ranged from 20 to 100, and practice levels were categorized as: poor practice: <50, moderate practice: 51-75, good practice: 76-100.

Data collection procedure

After obtaining ethical clearance from the institutional ethics committee of Jamia Hamdard and administrative permission data were collected from 21st October to 8th November 2025 through face-to-face interviews using the paper-and-pencil method. Written informed consent was obtained from all participants prior to data collection. Confidentiality and anonymity were strictly maintained.

Ethical considerations

Ethical clearance was obtained from the institutional ethics committee of Jamia Hamdard, New Delhi. Permission was secured from the concerned Gram Panchayats. Participants were informed about the purpose of the study, voluntary participation, confidentiality of

responses, and their right to withdraw at any time without penalty. Ethical principles outlined in the Declaration of Helsinki were adhered to throughout the study.

Data analysis

The collected data were entered into Microsoft Excel to develop a master datasheet and were subsequently analyzed by the investigator using Microsoft Excel under the supervision of the guide and co-guide. Descriptive statistics, including frequency and percentage distributions, were used to summarize the demographic characteristics of the study participants. Knowledge and practice scores were analyzed using measures of central tendency and dispersion, namely mean, median, and standard deviation. The distribution of participants according to expressed practice scores was also computed.

Karl Pearson’s correlation coefficient was applied to assess the relationship between knowledge and expressed practices related to pesticide handling among farmers. The association between knowledge levels and selected demographic variables was examined using the Chi-square test with Yates’ correction.

RESULTS

Sociodemographic characteristics of the study participants (n=100)

A total of 100 farmers were included in the study (Table 1). The majority of participants were in the age group of 40-60 years, and males constituted a higher proportion than females. Most farmers had attained secondary or higher secondary education, while only a small proportion were illiterate.

Table 1: Sociodemographic characteristics of the study participants (n=100).

Variables	Category	Frequency (%)
Age group in years	<20	4 (4.0)
	21-30	19 (19.0)
	31-40	20 (20.0)
	40-60	38 (38.0)
	Above 60	19 (19.0)
Gender	Male	59 (59.0)
	Female	41 (41.0)
Education level	Illiterate	3 (3.0)
	Primary	17 (17.0)
	Secondary	37 (37.0)
	Higher secondary/diploma	27 (27.0)
	Graduation or above	16 (16.0)
Family monthly income (in rupees)	<10,000	34 (34.0)
	10,000-20,000	26 (26.0)
	20, 000-30,000	12 (12.0)
	Above 30,000	28 (28.0)
Farming experience (in years)	<5	14 (14.0)
	5-<10	15 (15.0)
	10-<15	27 (27.0)
	>15	44 (44.0)
Daily working hours in the field	1-4 hours	62 (62.0)
	5-<8 hors	31 (31.0)
	9-12 hours	6 (6.0)
	More than 15	1 (1.0)
Years of pesticide use	1-5	42 (42.0)
	6-10	31 (31.0)
	11- 15	15 (15.0)
	More than 15	12 (12.0)
Pesticide-related training	Yes	19 (19.0)
	No	81 (81.0)
History of pesticide poisoning	Yes	17 (17.0)
	No	83 (83.0)

In terms of socio-economic status, a considerable proportion of participants had a monthly family income below ₹10,000. The majority of farmers had more than 15 years of farming experience. Most participants reported working 1-4 hours daily in the field.

With regard to pesticide exposure, most farmers had been using pesticides for less than 10 years. Notably, a large proportion of participants had not received any pesticide-related training. A small but important proportion of farmers reported a history of pesticide poisoning.

Distribution of level of knowledge of farmers regarding pesticide handling

The possible knowledge score ranged from 0 to 28. The observed scores ranged from 5 to 28, with a mean score of 17.7 (SD=4.65) and a median score of 18, indicating an approximately normal distribution of scores.

Table 2: Distribution of level of knowledge farmers regarding pesticide handling.

Level of knowledge	Frequency	Percentage
Good (21-28)	26	26.0
Moderate (14-20)	56	56.0
Poor (0-13)	18	18.0

Table 3: Distribution of expressed practices of farmers regarding pesticide handling.

Category of practice	Frequency	Percentage
Good (76-100)	78	78.0
Moderate (51-75)	22	22.0
Poor (20- 50)	0	0.0

Table 4: Correlation between knowledge and expressed practices.

Variables	Mean	SD	r- value	P value
Knowledge	17	4.65	0.39	0.0004*
Expressed practice	80.68	8.28		

*p<0.05 value, significant at 0.05 level.

Table 5: Association between knowledge and selected demographic variables.

Demographic variables	Level of knowledge scores			df	χ ² value	P value
	Good	Moderate	Poor			
Age in years						
<20	1	1	2	8	6.018	0.645
21-30	3	12	4			
31-40	5	10	5			
41-60	11	21	6			
Above 60	7	10	2			
Gender						
Male	18	34	7	2	4.20	0.12
Female	8	22	11			
Education						
Illiterate	1	1	1	8	18.16	0.016*
Primary	1	8	8			
Secondary	10	23	4			
Higher secondary/diploma	6	17	4			
Graduation or above	8	7	1			
Years of pesticide use in farming						
<5	14	22	6	6	3.87	0.690
5-<10	6	20	5			
10-<15	4	7	4			
>15 years	2	7	3			
Pesticide related training						
Yes	6	5	8	2	11.54	0.003*
No	20	51	10			

*p<0.05 value, significant at 0.05 level.

Based on predefined scoring criteria, the majority of farmers had a moderate level of knowledge, while a smaller proportion demonstrated good knowledge. However, a notable proportion still had poor knowledge. (Table 2).

Distribution of expressed practices of farmers regarding pesticide handling

The possible range of expressed practice scores was 20-100. The observed practice scores ranged from 62 to 99, with a mean score of 80.68 (SD=8.28) and a median score of 80, suggesting relatively high reported adherence to safe practices. Based on the categorization criteria, most farmers reported good practices related to pesticide handling, with the remaining participants falling under the moderate category. No participants were found to have poor practices (Table 3).

Correlation between knowledge and expressed practices

Karl Pearson's correlation coefficient was calculated to assess the relationship between knowledge and expressed practices regarding pesticide handling. The analysis revealed a positive correlation between knowledge scores and practice scores, which was statistically significant ($p < 0.05$). This finding suggests that higher levels of knowledge regarding pesticide handling were associated with better expressed practices among farmers (Table 4).

Association between knowledge and selected demographic variables

Chi-square analysis was performed to examine the association between knowledge levels and selected demographic variables. Educational status and pesticide-related training showed a statistically significant association with knowledge levels ($p < 0.05$). Farmers with higher educational attainment and those who had received training demonstrated better knowledge regarding pesticide handling (Table 5).

No statistically significant association was observed between knowledge levels and other demographic variables such as age, gender, or years of pesticide use ($p > 0.05$).

DISCUSSION

The present study reveals that more than half of farmers (56%) possessed a moderate level of knowledge regarding pesticide handling, while 26% demonstrated good knowledge and 18% exhibited poor knowledge. These findings are consistent with the study conducted by Sachan et al to evaluate farmers' cognizance of pesticide usage, overuse, and management strategies in rural areas of Lucknow district.¹² Their results similarly highlighted inadequate knowledge of safe pesticide use, with 55% of farmers not reading or following pesticide labels and 80.2% being unaware of banned or restricted pesticides.

Additionally, 37% lacked awareness that certain pesticides could cause fatal intoxications, underscoring substantial gaps in understanding risks associated with improper pesticide handling. It emphasizes that farmers' limited knowledge of pesticide hazards and unsafe handling practices pose serious health and environmental risks. The present study found that the majority (78%) of farmers followed moderate practice and 22% of them had good practice. The mean score of expressed practice of farmers was 80.68, the median is 80, and the standard deviation was ± 8.28 . Consequently, the findings of the present study were consistent with the previous study conducted by Sai et al, to evaluate farmers' knowledge, attitudes, and practices regarding pesticide usage and its toxic effects, involving 171 farmers who were interviewed using a standardized questionnaire.¹⁰ Their results similarly highlighted a gap between awareness and actual safe practices: although 61% of farmers were aware of the harmful effects of pesticides, unsafe behaviors were still prevalent, with 22% mixing pesticides with bare hands and 67% disposing of residues in open fields. The congruence between the present study and previous findings reinforces the need for strengthening educational and intervention programs aimed at improving safe farming practices.

The present study highlights a positive correlation between the knowledge and expressed practice. These findings are consistent with a study by Kumar et al, a cross-sectional survey among 302 farmers in rural areas of the Doiwala block, Dehradun district, Uttarakhand, to assess knowledge, practices, and associated health symptoms.²⁰ Their study similarly observed that farmers with higher knowledge scores demonstrated better compliance with safe pesticide-handling practices, showing a positive linkage between awareness and behaviour. Moreover, Kumar et al also reported that inadequate knowledge was associated with unsafe practices such as improper storage, lack of personal protective equipment use, and unsafe disposal methods, further reinforcing the relationship between knowledge and practice.²⁰

The present study is further supported by the findings of Lari et al, who examined farmers' demographic characteristics and knowledge and pesticide-related handling practices in rural Telangana.³¹ They reported that farmers with higher educational attainment exhibited greater awareness of pesticide-related risks and were more likely to engage in safer handling practices, whereas those with lower literacy levels frequently demonstrated hazardous behaviours such as neglecting PPE use, prematurely re-entering treated fields, and improperly disposing of containers. This pattern reflects an implicit positive association between education and knowledge ($p = 0.016$), aligning with the significant relationship with practice ($p = 0.0004$) identified in the current study. Additionally, Lari et al emphasized that the absence of formal training contributed substantially to inadequate knowledge and unsafe pesticide-handling behaviours,

supporting the highly significant association observed between training and knowledge in the present study ($p=0.003$).³¹ Congruent to the findings of the current research, their study did not provide strong evidence that age or farming experience independently influenced farmers' knowledge levels, thereby suggesting that such demographic factors may not enhance knowledge in the absence of structured training or educational support.

The present study on pesticide handling among farmers is further supported by Karki et al to assess farmers' knowledge and practices associated with pesticide handling in Bardiya District, Nepal.²⁴ The findings revealed that only 34.5% of farmers had adequate knowledge of safe pesticide use, with particularly poor knowledge of reading instructions (20.2%) and recognizing symptoms (21.3%). While 86.8% of farmers had adequate practices overall, there were still significant limitations, as only 2.1% of farmers took a full set of personal protective equipment and disposal methods were found to be unsafe. They found a significantly moderate positive correlation between knowledge and practice ($r=0.458$, $p<0.001$), which corresponded to a significant relationship identified in the present study between knowledge and practice ($r=0.39$, $p<0.05$). Furthermore, Karki et al indicated that years of pesticide use, exposure to social media, and training were all predictors of higher knowledge, consistent with the present study's finding of a strong association between training and knowledge ($p=0.003$). Additionally, and like the present study, Karki et al also indicated that demographic factors such as age and years of farming experience were not independent motivators of knowledge, which emphasizes the conclusion made in both studies that providing structured training and education platforms is how farmers' knowledge and practices can be improved.

A study conducted by Senapati et al investigated the knowledge and practices of farmers regarding the safe use of pesticides using semi-structured questionnaire in a district of Odisha, India.²⁹ All farmers reported using pesticides, with 47.50% having over 15 years of farming experience and 68.65% using pesticides for 5-15 years. The overall knowledge about safe pesticide use was poor (68.4%), and practices were even poorer (61.53%). A significant majority (92.63%) had not attended any training on integrated pest management (IPM). However, the present study was conducted in a district of Himachal Pradesh, which used a structured interview schedule to assess knowledge and a 5-point rating scale to assess expressed practices among farmers. Mostly farmers were between 41-60 years, only 2% were illiterate in the present study. The majority (44%) of them had over 15 years of farming experience and had been using pesticides for 1-5 years. Overall, 56% of respondents had a moderate understanding of handling pesticides, and 78% reported having good practice. It was found that only 19% had gone to training on pesticides, and most (91%) had not.

CONCLUSION

In conclusion, the findings of the present study align with the broader body of research indicating that farmers generally possess moderate knowledge regarding pesticide handling, which can be effectively enhanced through regular and structured training programs. The positive influence of knowledge on safe practice elaborates the importance of continuous educational and awareness initiatives. Nonetheless, to achieve consistent adherence to safety standards, future efforts must address practical and attitudinal barriers, ensuring that safety measures such as PPE use and proper pesticide management become integral components of routine agricultural practice.

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