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*Original Article*

# Health Effects of Pesticides among Small-scale Farmers in an Urban Municipality of Nepal: A Descriptive Study

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## ABSTRACT

**Introduction:** Pesticides cause short-term as well as long-term health effects. Agriculture workers are at high risk of effect. So, this study aimed to identify the health effects of pesticides among small-scale farmers in the municipality of Bhaktapur, Nepal.

**Methods:** This was a community-based cross-sectional descriptive study conducted in all wards of Changunarayan Municipality, Bhaktapur, Nepal. Farmers of selected households who adopted agriculture as their main occupation were included in this study. The sample size for the study was 132. Proportionate stratified sampling was used to determine the farmer from each ward and simple random sampling was used to reach every respondent. Face-to-face interview technique and semi-structured questionnaire was used for data collection. The data were analyzed using descriptive statistics and the Chi-square test was applied to measure an association between selected variables.

**Results:** All of the farmers used pesticides and about two-thirds 74(64.9%) experienced both immediate as well as delayed symptoms due to the use of pesticides. Majority of them showed general symptoms such as eye irritation 87(76.3%), difficulty in breathing 70(61.4%) and fatigue 55(48.2%). There was an association between the frequency of exposure and health effects due to pesticide use which was found to be statistically significant at a significance level with *p*-value 0.042.

**Conclusion:** Health effects such as skin rashes, effects on the eyes, and respiratory system were reported. The most prevalent effects were eye irritation, difficulty in breathing, and itching of the skin. Training on pesticide use and awareness should be conducted by municipalities to reduce the effects.

**Keywords:** Farming, Health effects, Pesticide effects, Pesticide use

## Introduction

Pesticides are those substances that are used to get rid of, control, and repel the harmful biota which has the potential to destroy vegetation, crops, farmland, and animals. Human exposure to pesticides has been documented through many routes such as dietary intake, indoor pesticide exposure, and outdoor exposure and even secondarily through animal upon the consumption of animal products and on many levels such as mild pesticide poisoning, moderate poisoning, and severe poisoning.[1,2]

WHO has classified pesticides according to the hazard they pose, the hazard, in this case, being the acute risk to the health of people who are actively using pesticides. This classification is based on the Acute Toxicity Hazard Category which was developed by GHC (The globally harmonized system of classification and labeling of chemicals) into classes which are Ia (Extremely Hazardous), Ib ( Highly hazardous), II ( Moderately hazardous), III ( Slightly hazardous) and U (Unlikely to present acute hazard).[3] Agriculture being one of the major occupation of people all around the world has more than a billion workers actively working which is why it is also considered one of the most dangerous occupations with nearly 170,000 deaths annually.[4]

The use of pesticides in an extensive way and period, lack of proper knowledge about the handling of the pesticides, lack of regulation in the proper labeling and marketing of pesticides, as well as the language barriers on the labels in the pesticide containers, have been seen as some of the major reasons why pesticides have affected on the health of farmers.[5] Studies suggest that female workers are at double the risk of having pesticide poisoning than their male counterparts, and that gender equity also plays a vital role in the reduction of the use of pesticides.[6,7]

The global pesticide usage has significantly increased with the increase in the population and food consumption rate. However, Nepal is relatively low in the usage of active ingredients in pesticides (396g/ha) compared to developed countries like China and India.[8] A Maximum Residual Limit (MRL) has been developed by WHO in order to decrease the health risk possessed by the use of these active ingredients.[3,8]

Intervention programs which included training the farm workers and the pesticide retailers resulted in an improved level of practice and knowledge about pesticides, their consumption, and management.[9]

In the Philippines, a study revealed that the application of spraying the pesticide in the field (63.7%) was the major way through which farmers were getting exposed to the pesticides, and among the farmers, nearly half (49%) complained of being sick due to the agricultural works.[10] A study of tea plantation workers in India revealed that over half of the sprayers experienced musculoskeletal complaints.[11]

A study in Tanzania shows that among the farmers taken in the study, 68% reported that they felt ill with symptoms of health-related issues such as skin problems and neurological problems like headache and dizziness.[12]

A study in Ethiopia showcased a significant association between the exposure and the response to the occupational exposure of pesticide with reduced lung capacity and function, and several respiratory symptoms.[13]

A study in Thailand among the farmers who were exposed to pesticides suggested symptoms like difficulty in breathing (47.2%), nausea/vomiting (46.9%) followed by diarrhea and rashes.[4]

Nepal is also a country where pesticide consumption has been rampant with an increase of 10-20% annually, mostly in the *Terai* region and Kathmandu Valley.[14] A study in Nepal revealed that farmers who have had exposure to pesticides developed more symptoms of pesticide intoxication than the respective control group (mean 5.47 versus 2.02 respectively).[15] So, this study aimed to assess the perceived health effect of pesticide use by farmers in small-scale farming in Changunarayan Municipality, Bhaktapur, Nepal.

## Methods

A community-based cross-sectional descriptive study was conducted among professional small-scale farmers from May to October 2022 in all nine wards of Changunarayan Municipality, Bhaktapur, Nepal. The sample size was calculated using Cochran's formula ($z^2pq/e^2$) with the prevalence of acute effect of pesticides from the previous study as 9.5%,[16] and 5% margin of error. The final sample size was 132. Data collection was done from July 1st to 15th, 2022. There were altogether 1191 households adopting farming as the main occupation from the municipality records. Proportionate stratified sampling was used to determine the farmer from each ward and simple random sampling was used to reach every respondent. One eligible participant was surveyed from each household. If there were more than one eligible person in the household, one participant was chosen by lottery method. After the estimated sample was covered in one ward, we moved to the next ward.

Ethical clearance was obtained from the institutional review committee of the Central Institute of Science and Technology (CiST) college (Ref. no: IRC162/078/079). Written informed consent was taken from each respondent and confidentiality was also maintained. Data was collected through face-to-face interviews. After an extensive literature review and multiple discussions within the research team, the

questionnaire was designed for the study.[16] The questionnaire was divided into three sections: first section with socio-demographic characteristics, second section with pesticide-related questions, and third section with behavior-related questions. Participants were given considerable time to record all their experiences during data collection.

The collected data was cleaned and edited on the same day of data collection. Epi-Data version 3.1 was used for data entry and checks were defined. To minimize the error within the limit, 10% of the randomly selected data was manually rechecked. Entered data were exported from Epi-Data to SPSS (version 22) for further analysis. Based on the objective of the study the data was analyzed using descriptive statistics. Categorical variables were described using numbers and percentages where non-normally distributed data was presented as median and interquartile range. Frequency distribution and cross-tabulation between dependent and independent variables were used to describe the basic background and respondent characteristics. The chi-square test was used to measure the association between the independent and the dependent variables. The *p*-value less than 0.05 was considered to be significant.

## Results

### Socio-demographic findings

The majority of the respondents 85(64.4%) were male and the median age was 41 years. More than three-fourths of the respondents were married 103(78.8%) and followed Hinduism 119(90.2%). The majority of respondents were from Advantaged *Janajati (Newar) 60* (45.5%) as their ethnicity. About one-third of the respondents 42(31.8%) had completed secondary level education and 130(98.5%) of them were involved in the production of food crops, vegetables 122(92.4%), and livestock products 92 (69.7%) (Table 1).

### Pesticide Related Characteristics

All the farmers were found to use pesticides on their farms, and half of 66(50.0%) used pesticides on their fields at least once in the last three months before the time of study. More than three-fourths 108(81.8%) of farmers had less than three hours of pesticide exposure, Inhalation 127 (96.2%) followed by skin exposure 60 (45.5%) were the main route of pesticide exposure. All farmers 132 (100%) used a sprayer as the most common pesticide use method followed by dusting 73(55.3%) and Granular Application 26(19.7%). All of the farmers used Personal Protective Equipment (PPE) when using pesticides. Less than one-fifth of 25 (19%) farmers received training for pesticide use (Table 2).

**Table 1: Socio-Demographic Characteristics (n=132)**

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| **Age (Median, IQR)** | (41,19) | |
| **Sex** | | |
| Male | 85 | 64.4 |
| Female | 47 | 35.6 |
| **Ethnicity** | | |
| Dalit | 3 | 2.3 |
| Advantaged *Janajati*(*Newar*) | 60 | 45.5 |
| Brahmin | 13 | 9.8 |
| Chettri | 56 | 42.4 |
| **Educational Status** | | |
| Illiterate | 8 | 6.1 |
| Non-Formal Study | 3 | 2.3 |
| Primary Level | 27 | 20.4 |
| Secondary Level | 42 | 31.8 |
| Higher Secondary Level | 35 | 26.5 |
| Bachelors | 14 | 10.6 |
| Masters | 3 | 2.3 |
| **Type of Agricultural Products*** | | |
| Food Crops | 130 | 98.5 |
| Fruits | 27 | 20.5 |
| Livestock Products | 92 | 69.7 |
| Vegetables | 122 | 92.4 |

**Multiple response*

**Table 2: Pesticide Related Characteristics (n=132)**

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| **Frequency of Exposure** | | |
| Once | 66 | 50 |
| More than once | 66 | 50 |
| **Time of exposure** | | |
| ≤3 hours | 108 | 81.8 |
| >3 hours | 24 | 18.2 |
| **Route of Exposure*** | | |
| Inhalation | 127 | 96.2 |
| Skin Exposure | 60 | 45.5 |
| Ingestion | 10 | 7.6 |
| **Methods of Pesticide Use*** | | |
| Spraying | 132 | 100 |
| Dusting | 73 | 55.3 |
| Granular Application | 26 | 19.7 |
| Soil Drenching | 1 | 0.8 |
| **Training for Pesticide Use** | | |
| Yes | 25 | 18.9 |
| No | 107 | 81.1 |

**Multiple response*

**Health Effects Due to Pesticide**

The majority of farmers 114 (86.4%) stated that they had various symptoms of health consequences due to pesticide use. The usage of pesticides resulted in both immediate and delayed effects for the farmers 74 (64.9%). The majority of farmers experienced general symptoms like fatigue 55(48.2%), difficulty in breathing 70 (61.4 %), and eye irritation 87(76.3%). Following the use of pesticides, some study respondents experienced skin itch 89(81.7%) followed by irritation 53 (48.6%) and redness 51 (46.8%). Most of the respondents 98 (93.3%) reported itchy eyes whereas more than one-third (37.1%) reported watery eyes as the main effects of pesticides on them. The two main effects on the respiratory system caused by the use of pesticides were coughing 60(58.3%) and shortness of breath 73(70.9%). Vomiting was reported by nearly two-thirds of respondents 28(65.1%), followed by irritability 18(41.9%), and decreased sleep 6(14.0%) as the pesticide's main adverse effects on the gastrointestinal system (Table 3).

**Association between health effects due to pesticide uses and behavioral characteristics**

The association between behavioral characteristics and health effects due to pesticide use is given in Table 4. Smoking status is classified as non-smoker, daily, and sometimes smokers. The respondent who has not smoked different types of smoking is considered a non-smoker. A daily smoker is someone who smokes cigarettes or uses other tobacco products daily and has developed regular habits. A sometime smoker, also known as an occasional or social smoker, is a person who smokes cigarettes or uses other tobacco products only occasionally or in specific social situations. This explanation is also applied to tobacco use and alcohol consumption.

The association between the time of exposure, the smoking status, alcohol consumption status tobacco consumption status, and health effects due to pesticide usage were not statistically significant but the frequency of exposure was significantly associated with health effects due to the use of pesticides ($p$=0.042).

**Table 3: Health effects due to pesticide use**

| Characteristics | Attributes | Frequency | Percentage (%) |
|---|---|---|---|
| **Observation of Symptoms (n=132)** | Yes | 114 | 86.4 |
| | No | 18 | 13.6 |
| **Types of Symptoms (n=114)** | Immediate (Within an hr.) | 31 | 27.1 |
| | Delayed (Within 24 hrs.) | 9 | 7.8 |
| | Both | 74 | 64.91 |

| | | | |
|---|---|---|---|
| **General Symptoms* (n=114)** | Fatigue | 55 | 48.2 |
| | Body Ache | 33 | 28.9 |
| | Fever | 16 | 14.0 |
| | Eyes Irritation | 87 | 76.3 |
| | Difficulty Breathing | 70 | 61.4 |
| **Effects on Skin*(n=109)** | Rashes | 14 | 12.8 |
| | Irritation | 53 | 48.6 |
| | Itching | 89 | 81.7 |
| | Redness | 51 | 46.8 |
| **Effects on Eyes* (n=105)** | Red Eyes | 57 | 54.3 |
| | Watery Eyes | 39 | 37.1 |
| | Itchy Eyes | 98 | 93.3 |
| | Blurry Vision | 6 | 5.7 |
| **Effects on the Respiratory System (n=103)** | Cough | 60 | 58.3 |
| | Wheeze | 11 | 10.7 |
| | Chest Pain | 37 | 35.9 |
| | Shortness of Breath | 73 | 70.9 |
| **Effects on the Gastrointestinal System* (n=43)** | Abdominal Pain | 3 | 7.0 |
| | Vomiting | 28 | 65.1 |
| | Diarrhea | 2 | 4.7 |
| | Irritability | 18 | 41.9 |
| | Trembling Hands | 2 | 4.7 |
| | Decreased sleep | 6 | 14.0 |
| | Decreased Concentration | 3 | 7.0 |

**Multiple response*

**Table 4: Association between behavioral characteristics and health effects due to pesticide use(n=132)**

| Variables | Health effects due to use of pesticide | | *p*-value |
|---|---|---|---|
| | Yes n (%) | No n (%) | |
| **Time of Exposure** | | | |
| ≤3hours | 92(85.2) | 16(14.8) | 0.611 |
| >3hours | 22(91.7) | 2(8.3) | |
| **Frequency of exposure** | | | |
| Once | 53(80.3) | 13(19.7) | 0.042* |
| More than once | 61(92.4) | 5(7.6) | |
| **Smoking Status** | | | |
| Non smoker | 63(91.3) | 6(8.7) | |
| Daily | 48(81.4) | 11(18.6) | 0.174† |
| Sometimes | 3(75.0) | 1(25.0) | |
| **Alcohol consumption status** | | | |
| Non user | 67(85.9) | 11(14.1) | |
| Daily | 1(100.0) | 0(0.0) | 1.00† |
| Sometimes | 46(86.8) | 7(13.2) | |
| **Tobacco Consumption status** | | | |
| Non user | 88(88.0) | 12(12.0) | |
| Daily | 24(80.0) | 6(20.0) | 0.526† |
| Sometimes | 2(100.0) | 0(0.0) | |
| **Training for pesticide** | | | |
| Yes | 23(92.0) | 2(8.0) | 0.556 |
| No | 91(85.0) | 16(15.0) | |

**Significant p-value at <0.05, †P-value from Fisher's exact test*

## Discussion

Changunarayan municipality lies in the Bhaktapur district. Changunarayan municipality extensively follows agriculture as the main occupation. Most of the ethnic groups of the municipality were *Janajati (Newars*) who are the primary inhabitants of the Bhaktapur district and who have been involved in agriculture for centuries. The major crops grown in the municipalities were food crops such as rice, wheat, maize, and vegetables. Our study revealed that all of the farmers used pesticides when growing vegetables to control insects and pests. The pesticide has been used on a large scale yearly, due to the growing concern of pests and vector-borne diseases.[17]

In this study, spraying was seen as the major method for the use of pesticides all of the farmers were using. Spraying is the easiest method of using pesticides. Other studies also suggested that spraying had been the major method for the use of chemical pesticides in both the western as well as eastern communities of the world.[18] More than half of the farmers use sprayers for powder pesticides on their farms, consistent with a study conducted in Lalitpur Nepal.[19] This study found that the farmers suffered from respiratory problems such as shortness of breath 73(70.9%), cough 60(58.3%), and chest pain 37(35.9%) which was similar to findings from Thailand which revealed that the prevalence of difficulty in breathing and chest pain was significantly higher in farmers than in the controls (OR 2.8, $P < 0.01$ and OR 2.5, $P < 0.05$, respectively).[20] This study has showcased the complete use of PPE sets despite showing major health problems such as respiratory and dermal problems, in contrast to the study in Ecuador which suggested very little use of PPE resulting in health problems.[21] This might be due to the use of non-health-approved masks, leaky backpack sprayers, and less use of boots. These reasons can be valid as the sprayers in Nepal are quite expensive and the fact that the result also revealed that very few people were trained for pesticide use.

This study revealed that fatigue, body aches, fever, eye irritation, and difficulty breathing were some of the major symptoms that were faced due to the use of pesticides. Several previous studies also reported that chronic fatigue and irritability were some of the most common health effects due to the use of pesticides.[22,23] This study also showcased various effects on the ophthalmic systems such as redness, itching, watery eyes, and blurry vision. Various studies conducted on the effects of organophosphate on the ophthalmic system have concluded that these symptoms could be attributed to the postsynaptic acetylcholine accumulation which results from the acetylcholine inhibition by these organophosphates.[24] The psychological symptoms including irritability, trembling of hands, decreased sleep, and decreased concentration have been recorded. Studies have shown that it is possible due to the long-term exposure of organophosphates in a small amount causing chronic neuropsychological effects and neurotoxicity.[25]

The major respiratory problems in this study were cough, wheezing, shortness of breath, and chest pain. A study on the low-level exposure to organophosphate leading to restrictive lung dysfunction showed that the organophosphates affected the respiratory system through the nicotinic action on the respiratory-muscles and the medullar center as well as direct toxic effects on the alveolar-capillary membrane.[26] Studies have also shown that the effects on the skin such as irritation, itching, and redness are due to the localized effects.[27]

This study has shown that the frequency of exposure was statistically significant ($p$-0.042) with the health effects due to pesticide usage. The frequency of pesticide use was significantly associated with exposure to pesticides, and exposure has been associated with chronic health effects thus backing up the evidence.[28]

Regarding training for the use of pesticides, most of the respondents 107(81.1%) weren't subjected to any training for the proper and rational use of pesticides. In Nepal, the training for the proper use of pesticides is given to the reseller more than the actual farmers who work in the field, however, District Agricultural Offices and Regional Training Centers have also conducted training for the safe use of pesticides at a consumer's level. Rapid Bioassay of Pesticide Residue (RBPR) laboratory has been established in Jhapa, Rupandehi, Banke, Kaski, Sarlahi, and Kailali districts of Nepal due to its positive impact.[29] RBPR isn't established in the Bhaktapur district which could have impacted the number of people training for the use of pesticides.

## Limitations

The study is subjected to recall bias as the recall period for symptom identification was three months. This study was done in a limited sample size and only in one municipality of Nepal so findings could not be generalized to the whole farming population of the country. The effects of pesticides were reported by the respondent self,

and no clinical measures or laboratory tests were applied to verify the symptoms.

## Conclusions

All of the farmers used pesticides to grow food crops, vegetables, and animal products in Changunarayan Municipality, Bhaktapur, Nepal. Most of the farmers experienced both immediate as well as delayed symptoms, the majority showing general symptoms such as eye irritation, difficulty breathing, and fatigue. The frequency of exposure and effects of pesticide use were statistically significant. The municipality should focus on providing knowledge about the use of pesticides and training for the farmers at the production level and the methods for the safe and rational use of pesticides.

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## References

1. Del Prado-Lu JL. Pesticide exposure, risk factors and health problems among cutflower farmers: a cross sectional study. J Occup Med Toxicol. 2007 Sep 18.[Cited 2022 Jan 4];2:1-9. Available from: https://link.springer.com/article/10.1186/1745-6673-2-9
2. Gesesew HA, Woldemichael K, Massa D, Mwanri L. Farmers Knowledge, Attitudes, Practices and Health Problems Associated with Pesticide Use in Rural Irrigation Villages, Southwest Ethiopia. PLoS One. 2016 Sep 13.[Cited 2022 Jan 4];11(9):1-13. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0162527
3. World Health Organization. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification Geneva: World Health Organization; 2019 [Internet].Cited 2022 Jan 5]. Available from: https://apps.who.int/iris/bitstream/handle/10665/332193/9789240005662-eng.pdf.
4. Kangkhetkron T, Juntarawijit C. Factors Influencing Practice of Pesticide Use and Acute Health Symptoms among Farmers in Nakhon Sawan, Thailand. Int J Environ Res Public Health. 2021 Aug 20.[Cited 2022 Feb 10];18(16):1-12. Available from: https://pubmed.ncbi.nlm.nih.gov/34444547/#:~:text=This%20study%20found%20about%2040,practice%20(p%20%3C%200.05)
5. Hutter HP, Poteser M, Lemmerer K, Wallner P, Kundi M, Moshammer H, et al. Health Symptoms Related to Pesticide Use in Farmers and Laborers of Ecological and Conventional Banana Plantations in Ecuador. Int J Environ Res Public Health. 2021 Jan 27.[Cited 2022 Feb 10];18(3):1-12. Available from: https://www.mdpi.com/1660-4601/18/3/1126
6. Cole DC, Orozco TF, Pradel W, Suquillo J, Mera X, Chacon A, et al. An agriculture and health inter-sectorial research process to reduce hazardous pesticide health impacts among smallholder farmers in the Andes. BMC Int Health Hum Rights. 2011 Nov 8.[Cited 2022 Feb 12];11 (2):1-6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22165981
7. Gyenwali D, Vaidya A, Tiwari S, Khatiwada P, Lamsal DR, Giri S. Pesticide poisoning in Chitwan, Nepal: a descriptive epidemiological study. BMC Public Health. 2017 Jul 3.[Cited 2022 Feb14];17(1):1-8. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-017-4542-y#auth-Prakash-Khatiwada-Aff4
8. Kafle S, Vaidya A, Pradhan B, Jors E, Onta S. Factors Associated with Practice of Chemical Pesticide Use and Acute Poisoning Experienced by Farmers in Chitwan District, Nepal. Int J Environ Res Public Health. 2021 Apr 15.[Cited 2022 Apr 20 ];18(8):1-14. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8071468/#:~:text=Farmers%20with%20unsafe%20practices%20of,of%20safe%20use%20of%20pesticide.
9. Koju P, Shakya PR, Shrestha A, Karmacharya BM, Shrestha S, Jaacks LM. Pilot Educational Intervention to Promote Safe Pesticide Use Practices Among Farmworkers in Nepal. Ann Work Expos Health 2020 Oct 8.[Cited 2022 Apr 20];64(8):866-75. Available from: https://pubmed.ncbi.nlm.nih.gov/32491155/
10. Lu JL. Assessment of Pesticide-Related Pollution and Occupational Health of Vegetable Farmers in Benguet Province, Philippines. J Health Pollut. 2017 Dec.[Cited 2022 Apr 20];7(16):49-57. Available from: https://pubmed.ncbi.nlm.nih.gov/30524840/
11. Ramesh N, Kannan R. Work-related musculoskeletal disorders among pesticide sprayers of tea plantations in South India. Int J Occup Safety Health. 2022 Jan 1.[Cited 2022 Apr 20];12(1):23-8. Available from: https://doi.org/10.3126/ijosh.v12i1.41034
12. Marete GM, Lalah JO, Mputhia J, Wekesa VW. Pesticide usage practices as sources of occupational exposure and health impacts on horticultural farmers in Meru County, Kenya. Heliyon. 2021 Feb.[Cited 2022 Apr 22];7(2):1-13.

Available from: https://pubmed.ncbi.nlm.nih.gov/33659728/

13. Negatu B, Kromhout H, Mekonnen Y, Vermeulen R. Occupational pesticide exposure and respiratory health: a large-scale cross-sectional study in three commercial farming systems in Ethiopia. Thorax. 2017 Jun.[Cited 2022 Apr 25];72(6):498-99. Available from: https://pubmed.ncbi.nlm.nih.gov/27879416/
14. Khanal G, Singh A. Patterns of Pesticide Use and Associated Factors Among the Commercial Farmers of Chitwan, Nepal. Environ Health Insights. 2016 Dec 11.[Cited 2022 Apr 25];10(Suppl 1):1-7. Available from: https://pubmed.ncbi.nlm.nih.gov/27980419/
15. Neupane D, Jors E, Brandt L. Pesticide use, erythrocyte acetylcholinesterase level and self-reported acute intoxication symptoms among vegetable farmers in Nepal: a cross-sectional study. Environ Health. 2014 Nov 20.[Cited 2022 Apr 25];13(98):1-7. Available from: https://doi.org/10.1186/1476-069X-13-98
16. Nisar S, Muzaffer U, Kareem O. Acute Health Effects of Pesticide Exposure among Farmers Directly Involved with Spraying: A Cross-Sectional Pilot Study from Kashmir Valley. Int J Health Sci Res. 2021 May.[Cited 2022 Apr 27];11(5):169-77. Available from: https://www.ijhsr.org/IJHSR_Vol.11_Issue.5_May2021/IJHSR-Abstract.027.html
17. 1eyaratnam J. Health problems of pesticide usage in the Third World. Br J Ind Med. 1985.[Cited 2022 Aug 25];42(8):505. Available from: https://pubmed.ncbi.nlm.nih.gov/4016001/
18. Sekiyama M, Tanaka M, Gunawan B, Abdoellah O, Watanabe C. Pesticide usage and its association with health symptoms among farmers in rural villages in West Java, Indonesia. Environ Sci. 2007 Aug.[Cited 2022 Sep 5];14(Suppl):23-33. Available from: https://pubmed.ncbi.nlm.nih.gov/18382412/
19. Jyoti S, Lama P, Yadav A, Vaidya S, Joshi SK. Knowledge, attitude, and practice of pesticide use among agricultural workers of Lamatar Village Development Committee, Lalitpur District: A cross-sectional study. Int J Occup Safety Health. 2023 Jul 15.[Cited 2022 Sep 5];13(4):441-9. Available from: https://doi.org/10.3126/ijosh.v13i4.53257
20. Sapbamrer R, Nata S. Health symptoms related to pesticide exposure and agricultural tasks among rice farmers from northern Thailand. Environ Health Prev Med. 2013 Jul 9.[Cited 2022 Sep 5];19(1):12-20. Available from: https://pubmed.ncbi.nlm.nih.gov/23835647/
21. Cropper ML. Economic and health consequences of pesticide use in developing country agriculture: discussion. Am J Agr Econ 1994 Aug 1.[Cited 2022 Sep 18];76(3):605-07. Available from: https://onlinelibrary.wiley.com/doi/abs/10.2307/1243673
22. Behan PO. Chronic fatigue syndrome as a delayed reaction to chronic low-dose organophosphate exposure. J Nutr Environ Med. 2009 Jul 13.[Cited 2021 Sep 18];6(4):341-50. Available from: https://www.tandfonline.com/doi/abs/10.3109/13590849609007262
23. Rasoul GMA, Abou Salem ME, Mechael AA, Hendy OM, Rohlman DS, Ismail AA. Effects of occupational pesticide exposure on children applying pesticides. Neurotoxicology. 2008 Sep.[Cited 2022 Sep 18];29(5):833-38. Available from: https://doi.org/10.1016/j.neuro.2008.06.009
24. Pham H, Lingao MD, Ganesh A, Capasso JE, Keep R, Sadagopan KA, et al. Organophosphate retinopathy. Oman J Ophthalmol. 2016 Apr.[Cited 2022 Sep 25];9(1):49-51. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4785709/
25. Jamal G, Hansen S, Pilkington A, Buchanan D, Gillham R, Abdel-Azis M, et al. A clinical neurological, neurophysiological, and neuropsychological study of sheep farmers and dippers exposed to organophosphate pesticides. Occup Environ Med. 2002 Jul 1.[Cited 2022 Oct 10];59(7):434-41. Available from: https://oem.bmj.com/content/59/7/434
26. Peiris-John RJ, Ruberu DK, Wickremasinghe AR, van-der-Hoek W. Low-level exposure to organophosphate pesticides leads to restrictive lung dysfunction. Respir Med. 2005 Aug 16.[Cited 2022 Oct 10];99(10):1319-24. Available from: https://pubmed.ncbi.nlm.nih.gov/16102957/
27. Segura P, Chavez J, Montano LM, Vargas MH, Delaunois A, Carbajal V, et al. Identification of mechanisms involved in the acute airway toxicity induced by parathion. Naunyn Schmiedebergs Arch Pharmacol. 1999 Dec.[Cited 2022 Oct 10];360(6):699-10. Available from: https://pubmed.ncbi.nlm.nih.gov/10619188/
28. Damalas CA, Eleftherohorinos IG. Pesticide exposure, safety issues, and risk assessment indicators. Int J Environ Res Public Health. 2011 May 6.[Cited 2022 Nov 10];8(5):1402-19. Available from: https://www.mdpi.com/1660-4601/8/5/1402
29. Adhikari PR. An overview of pesticide management in Nepal. J Agric & amp; Environ 2018 May 12.[Cited 2022 Nov 10 ];18:95-105. Available from: https://doi.org/10.3126/aej.v18i0.19894