Changes in Perceptions and Practices of Farmers and Pesticide Retailers on Safer Pesticide Use and Alternatives: Impacts of a Community Intervention in Chitwan, Nepal

Authors: Vaidya, Abhinav, Gyenwali, Deepak, Tiwari, Sundar, Pande, Badri Raj, and Jørs, Erik

Source: Environmental Health Insights, 11(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/1178630217719270

Changes in Perceptions and Practices of Farmers and Pesticide Retailers on Safer Pesticide Use and Alternatives: Impacts of a Community Intervention in Chitwan, Nepal

Environmental Health Insights
Volume 11: 1–12

DOI: 10.1177/1178630217719270
SAGE

Abhinav Vaidya[1], Deepak Gyenwali[2], Sundar Tiwari[3], Badri Raj Pande[4] and Erik Jørs[5,6]

[1]Department of Community Medicine, Kathmandu Medical College, Kathmandu, Nepal. [2]Farming, Health and Environment Nepal Project, Nepal Public Health Foundation, Kathmandu, Nepal. [3]Department of Entomology, Agriculture and Forestry University, Rampur, Nepal. [4]Nepal Public Health Foundation, Kathmandu, Nepal. [5]Clinic of Occupational Medicine, Odense University Hospital, Odense, Denmark. [6]NGO Dialogos, Copenhagen, Denmark.

ABSTRACT: Unsafe use of hazardous pesticides is a neglected public health problem in developing countries. This survey evaluates the effects of a training program to increase awareness on harmful effects of pesticides and to enhance capacity for safe handling involving 57 trained farmers, 98 neighboring farmers, 94 control farmers, and 23 pesticide retailers from villages in Chitwan, Nepal. Knowledge and attitude–related variables improved in all 3 farmer groups, with a significant trend of better knowledge and attitude from trained to neighboring to control farmers (in 14/16 [87.5%] variables). In practice, there were significant differences among the groups with a trend from trained to neighboring to control farmers (in 10/26 [38.5%] variables).The pesticide retailers also improved on knowledge and practice. In conclusion, training farmers and pesticide retailers improved their knowledge and practice, with possible positive effect on neighboring farmers and control villages as well. An improved extension service to farmers is recommended.

KEYWORDS: Farmers, farmer field school, knowledge, Nepal, pesticides, practice

RECEIVED: February 27, 2017. **ACCEPTED:** June 15, 2017.

PEER REVIEW: Four peer reviewers contributed to the peer review report. Reviewers' reports totaled 604 words, excluding any confidential comments to the academic editor.

TYPE: Original Research

FUNDING: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study is supported by the CISU/Danish Government.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Abhinav Vaidya, Department of Community Medicine, Kathmandu Medical College, Sinamangal, Kathmandu, Nepal. Email: dr.abhinavaidya@gmail.com

Introduction

Pesticides form an important part in increasing agricultural production.[1] However, their ingredients have been shown to induce acute toxic effects in practice and in different experimental systems.[2] Exposure to chemical pesticides is one of the most significant occupational risks among farmers in the developing countries[3] as they can easily get in contact with the pesticides, for example, when mixing the chemicals or when applying them to the crops and when pesticide residues are carried home.[4] Use of pesticides is linked to long-term and short-term health effects such as headache, dizziness, skin irritation, and blurred vision among small-scale farmers.[5] Although pesticide poisoning is a global issue,[6] developing countries[7] are affected relatively more than the developed countries.[8]

Pesticide is a complex issue globally, and Nepal is no exception,[9] particularly in terms of the challenges that it brings.[10] Although its exact health impact among Nepalese population is not known due to lack of awareness among health workers and a good reporting system, studies have shown that farmers exposed to pesticides have a lower erythrocyte acetyl cholinesterase level,[11] often at a subclinical level.[12] Nepal, a developing country in South Asia, is an agro-based country where more than 173 common types of insecticides, 62 types of fungicides, and 24 different brands of herbicides are being used.[13] Over the years, with the introduction of high-yielding varieties and expansion of areas for the cultivation of rice, maize, wheat, and vegetables, Nepal has experienced an increasing tendency to use pesticides, by about 10% to 20% per year.[14] Furthermore, the increasing trend of pesticide use in market-oriented vegetables and fruit production in Nepal has been a major cost factor.[15]

As elsewhere, Nepali farmers also confront a particularly high risk of pesticide poisoning due to the added risk from their occupational exposure through pesticide management when mixing, applying, spraying, transporting, storing, taking care of equipment, reentering into the field, spillage, and doing careless disposal.[9] Poor knowledge and practice among farmers and retailers on proper protection, safe storage, and spraying interval before harvest leads to increased risk of pesticide poisoning.[16,17] Although this is true in case of Nepal too,[12,18] the problem is further accentuated by inadequacy of information or education on pesticide toxicity in its health and agriculture services system.[11] Although Integrated Pest Management (IPM) has been a major program of the government for 2 decades to mitigate irrational and overuse of chemical pesticides,[19,20] with Farmer Field School (FFS) training as the main strategy,[9,15,19,20] this is a first attempt at

Figure 1. Map of Nepal showing the location of Chitwan District (shown in red).

community level to integrate the health dimension into the intervention. Indeed, from an economic point of view too,[21] bringing health in the front as the primary motivation for bringing change can be a successful intervention strategy.[22]

Therefore, with the aim of promoting health of farmers and consumers by promoting healthy and sustainable food production, Nepal Public Health Foundation implemented "Farming, Health and Environment Nepal 2013/15 Project (FHEN)" in the Chitwan District of Nepal in April, 2013. This project was designed as a multisectoral approach to address the negative influence of pesticides on public health and the environment due to occupational and environmental exposure. Specifically, the project aimed to increase awareness among farmers and pesticide retailers about harm due to exposure to pesticides and enhance their capacity for safe handling of pesticides. This article describes the impacts of the project interventions by assessing changes in knowledge, attitude, and practice on proper use of pesticides and alternatives among the farmers and retailers by comparing data collected at project start and end.

Materials and Methods

Study design

This is a descriptive survey, comparing 2 cross-sectional studies conducted at project start and project end in Chitwan, an inner Terai district in the Central Development Region of Nepal. The study period covers 3 years from 2013 to 2015.

Study site, population, and sample

The Chitwan District is 1 of the 75 districts and is situated in Southern Nepal (Figure 1). In total, 5 villages of Chitwan were purposively selected as intervention sites (project villages) and another 5 as control (nonproject) villages (Figure 2) on recommendation of the local stakeholders. At least 1 farmer who had been actively working for at least 2 years as a farmer was selected from each intervention village to go for project training.

From the project villages, 60 farmers going for training were selected by the Farmers' Cooperatives and participated in the trainings and other activities conducted by the project (key farmers). A total of 100 neighboring farmers to whom knowledge and skill were assumed to be transferred by the trained farmers were selected by convenience when found at home (fellow farmers), and 100 control farmers, who did not receive any project interventions, were selected the same way from neighboring villages.

Administratively, all villages were divided into 9 wards and samples were taken proportionately based on household population size from all wards. Only 1 person who was mostly involved in agriculture activities from each household was taken as respondent. The same farmers who were interviewed in the baseline were intended to be interviewed in the follow-up, as far as possible. We ended up with 57 trained farmers, 98 neighboring farmers, and 94 control farmers who had a data set suitable for further analysis. A total of 23 pesticide retailers in the project villages and of the nearby market areas from where farmers of project villages usually purchase pesticides also received trainings and were included in the baseline and the follow-up surveys.

Intervention

The key farmers took part in FFS organized specifically for the purpose which provided 10 to 15 theoretical and practical courses about IPM, health, and environment. The project then

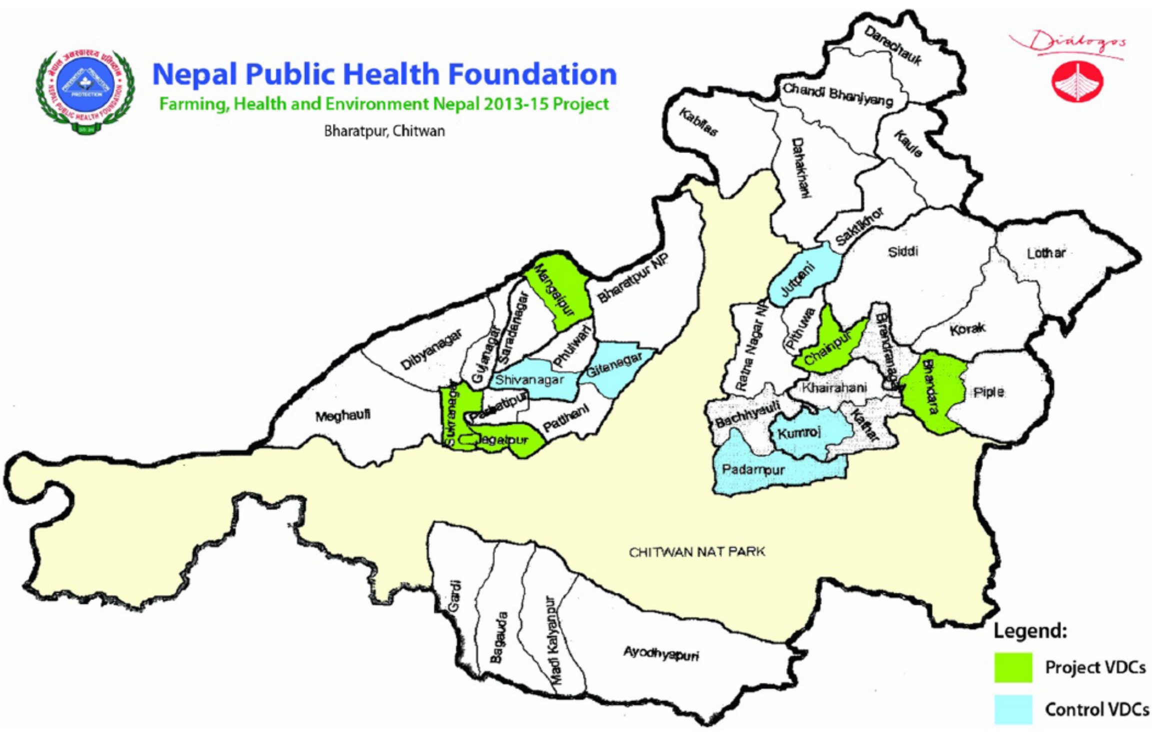

Figure 2. Map of Chitwan District showing project and control villages.

supported the trained key farmers in passing their acquired knowledge on to their neighboring fellow farmers acting as a kind of local consultant on pesticide matters in their villages.

The pesticide retailers were trained and they later participated in the education of the farmers in their pesticide shops to strengthen their knowledge of pesticide use and its safe handling, making them able to continuously supervise and educate the farmers' groups in the district. This information from the retailers might have reached the control group as well.

Data collection and variables

Face-to-face interviews in Nepali language were conducted with farmers and pesticide retailers using a structured questionnaire. In addition, direct observation method using observation checklist was applied to collect supplementary information in the household and pesticide retailers' survey. Questionnaires were adopted from validated standard tools applied in similar surveys from Uganda and Bolivia.[5,17] Questionnaires were translated into local Nepali language and modified into Nepali context. Questionnaires and observation checklists were pretested in a similar field setting before use in the actual survey. The farmers also reported whether they had any acute symptoms during handling and spraying of pesticides, such as headache, dizziness, dryness of mouth, muscle cramps, backache, etc.

Data management and analysis

The entire data set collected during the household survey was cleaned, coded, and entered into and analyzed with SPSS software version 22 (IBM, Armonk, NY, USA). Descriptive statistics such as mean and standard deviation were calculated for the continuous variables, and percentage distribution according to different characteristics of respondents was calculated for the categorical variables. The χ^2 test was applied for assessing differences in proportions for various variables among the 3 categories of farmers in the baseline and endline surveys.

Knowledge and attitude on pesticides and pest control among farmers was summarized in an aggregated variable comprising 16 variables. The variables are the ones presented in Table 2. For each positive response, a value of 1 was assigned, and for each negative response, a value of 0 was assigned. The total score was the summation of scores obtained in the 16 variables. Similarly, to measure the change in the level of the safety practices, an aggregate variable was developed using the 26 practice-related variables shown in Table 3.

We applied 1-way analysis of variance (ANOVA) to compare the aggregated scores across the 3 categories of farmers, at baseline and at endline. To control for possible confounders, we dichotomized the aggregated variables on knowledge/attitude and on practice and performed a logistic regression analysis. For both knowledge/attitude and safe practice aggregated variables, scores below the median values were considered as "low score" and were coded 1, and those equal to or higher were taken as "high scores" and coded 2.

Ethical considerations

The project received ethical approval from Nepal Health Research Council (NHRC) at the time of its implementation

(NHRC approval number: 113/2013). We obtained verbal consent from the study participants. The enumerators maintained confidentiality during the interviews. There was no possible harm to the participants because of the intervention or the surveys.

Results

The sociodemographic characteristics of the farmers who participated in the study are presented in Table 1. Significant differences were observed between the 3 categories of farmers for sex, area of arable land held, whether the farmers were members of any cooperative, and whether they had previously been trained in safer pesticide use or not. Mean age of all farmers was 41.8 (SD: 10.6) years with no significant difference between the 3 farmer groups regarding age.

Impact on knowledge and attitude of the farmers

Table 2 shows farmers' knowledge and attitude on various aspects of pesticide use, at baseline and at the endline survey. At baseline, the key farmers selected for trainings had better knowledge than their neighbors, whereas the latter had better knowledge than the controls on most variables. In 9 of the 16 variables, a significant trend was seen in a linear-by-linear analysis. After training, there was an improvement in most of the variables among all 3 groups of farmers with many of them being significant. A significant trend was now seen in 14 of the 16 variables in a linear-by-linear analysis. Figure 3 presenting an ANOVA analysis on the aggregated variable on knowledge and attitude shows a significant increase in score within all farmers' groups at the endline compared with their baseline. There was also a significant difference between all 3 groups at endline, which was not the case between the trained and neighboring farmers at baseline.

Impact on practices of the farmers

For most of the practice-related variables, positive changes were noted within all 3 categories of farmers with many of them being significant (Table 3). At baseline, the key farmers selected for trainings had better practice of handling pesticides as shown by higher proportion on better practice in most of the variables. There was a decreasing trend of these proportions from key farmers to neighboring to control farmers, and the differences were significant for 5 of the 26 variables as seen from a linear-by-linear analysis. At endline, the picture was the same but with 10 significant differences. Figure 4 presents an ANOVA analysis on the aggregated variable on practice. It shows a significant improvement within all 3 groups from baseline to endline. Although no significant difference was seen between the 3 groups at baseline, a significant difference was seen at endline.

In the controlled analysis, odds ratios were calculated for a score higher than median score in the aggregated variables for knowledge and attitude (Table 4). We saw that odds ratios were higher both at baseline and endline among trained farmers compared with the other 2 groups, although this difference in odds ratios was smaller at endline. In the practice variables, we saw a noticeable improvement in odds ratios from baseline to endline among both the trained and the neighboring farmers compared with the control farmers.

Impact on health of the farmers

The proportions of trained key farmers and fellow farmers reporting acute symptoms of pesticide poisoning immediately after spraying decreased from 51.7% to 30.8% ($P = .035$) and from 49.5% to 33.3% ($P = .023$), respectively. In comparison, the control farmers increased the number of symptoms from 31.3% to 37.0% ($P = .447$). Headache (20.9%), dizziness (12%), dryness of mouth (8.9%), muscle cramps (6.6%), backache (5.7%), and lethargy (5.7%) were the most commonly reported symptoms, followed by breathing difficulty (4.4%), difficulty in speaking (3.2%), abdominal pain (3.2%), and perspiration (2.5%).

Impact on perceptions and practices of the pesticide retailers

Of the 23 pesticide retailers, most of them were men (82.6%), aged ⩾30 years (73.9%) (mean age ± SD = 38.1 ± 11.8, range: 22-61 years), and education at least up to higher secondary level (60.6%). Three-fourths (78.3%) of the retailers were license-holding shop owners. Others (21.7%) were not license holders themselves but were staffs or relatives. Most of the retailers sold pesticides along with veterinary medicines (69.6%) or general goods (21.7%). In all, 21 had previously received training on pesticides.

Five variables related to knowledge on pesticides were assessed, and all were improved as shown in Table 5. Although the baseline survey revealed that 58.33% of the pesticide retailers were selling unregistered pesticides to the farmers, the endline survey found that none were selling them ($P < .001$) (Table 6).

Improvements were also found in counseling of farmers and in the sale of personal protective equipment (PPE), botanical pesticides, insect pheromones/attractants, and unregistered pesticides. However, there were reductions in the proportion of safe practices such as the use of PPE and selling of organic pesticides. Nonetheless, the endline result showed that there were improvements in common hygienic practices among pesticide retailers, although the changes were not statistically significant.

Discussion

The survey revealed a significant increase in the knowledge and practice level of pesticide handling and alternatives to pesticides in each of the 3 farmer groups from baseline to

Table 1. Sociodemographic characteristics of the farmers (Pearson χ^2 test).

VARIABLE	TRAINED FARMERS (N = 57)	FELLOW FARMERS (N = 98)	CONTROL FARMERS (N = 94)	*P* VALUE
	NO. (%)	NO. (%)	NO. (%)	
Age groups, y				
⩽40	29 (50.9)	50 (50)	41 (43.6)	.587
>40	28 (49.1)	50 (50)	53 (56.4)	
Gender				
Female	27 (47.4)	26 (26.5)	28 (29.8)	.022
Male	30 (52.6)	72 (73.5)	66 (70.2)	
Education				
Primary level or less	34 (59.6)	50 (51)	50 (53.2)	.576
Secondary level or above	23 (40.4)	48 (49)	44 (46.8)	
Smoking or chewing tobacco				
Yes	18 (31.6)	29 (29.6)	26 (27.7)	.874
No	39 (68.4)	69 (70.4)	68 (72.3)	
Alcohol intake				
Yes	6 (10.5)	17 (17.3)	14 (14.9)	.515
No	51 (89.5)	81 (82.7)	80 (85.1)	
Area of arable land, *kathas*[a]				
⩽17	27 (47.4)	63 (64.3)	65 (69.1)	.024
>17	30 (52.6)	35 (35.7)	29 (30.9)	
Years in farming				
<15	31 (54.4)	55 (56.1)	57 (60.6)	.712
⩾15	26 (45.6)	43 (43.9)	37 (39.4)	
Member of farmers' cooperative				
Yes	53 (93)	84 (85.7)	39 (41.5)	<.001
No	4 (7)	14 (14.3)	55 (58.5)	
No. of years using pesticides				
⩽10	36 (63.2)	69 (70.4)	66 (70.2)	.593
>10	21 (36.8)	29 (29.6)	28 (29.8)	
Trained in safer pesticide use				
Yes	13 (28.8)	20 (20.4)	5 (5.3)	.003
No	44 (77.2)	78 (79.6)	89 (94.7)	

[a]1 *katha* = 339 m^2.

endline. Trained farmers performed better than neighboring farmers, who in turn performed better than the control farmers both at baseline and endline on knowledge and attitude parameters. The same was seen for practice showing significant differences at endline among the 3 groups which was not the case at baseline. Less incidences of pesticide-related health symptoms were also noted among the trained and fellow farmers. The fact that the trained farmers improve

Table 2. Knowledge and attitude on pesticide use and alternatives among farmers seen in 16 variables compared at baseline and endline (Pearson χ^2 test and linear-by-linear association, significant positive differences marked with gray).

KNOWLEDGE VARIABLES	TRAINED FARMERS			FELLOW FARMERS			CONTROL FARMERS			BASELINE	ENDLINE
	BASELINE (N=57) NO. (%)	ENDLINE (N=47) NO. (%)	*P* VALUE	BASELINE (N=98) NO. (%)	ENDLINE (N=92) NO. (%)	*P* VALUE	BASELINE (N=94) NO. (%)	ENDLINE (N=89) NO. (%)	*P* VALUE	LINEAR-BY-LINEAR ASSOCIATION, *P* VALUE	LINEAR-BY-LINEAR ASSOCIATION, *P* VALUE
Prefers to use alternatives to pesticides	28 (49.1)	33 (70.2)	.030	49 (50)	39 (42.9)	.325	39 (41.5)	39 (44.8)	.650	.301	.015
Knows purpose of insecticides	50 (87.7)	44 (93.6)	.310	79 (80.6)	79 (85.9)	.333	74 (78.7)	73 (82)	.575	.189	.072
Knows purpose of fungicides	44 (77.2)	44 (93.6)	.021	75 (77.3)	78 (85.7)	.139	60 (63.8)	65 (73)	.181	.048	.002
Knows purpose of pheromone traps	16 (28.1)	11 (23.4)	.589	21 (21.4)	17 (18.5)	.611	9 (9.6)	6 (6.7)	.485	.005	.005
Knows purpose of plant antibiotics	25 (43.9)	23 (48.9)	.605	50 (51)	44 (47.8)	.660	20 (21.3)	33 (37.1)	.018	.001	.135
Knows purpose of biopesticides	16 (28.1)	26 (55.3)	.005	26 (26.5)	36 (39.1)	.064	8 (8.5)	18 (20.2)	.023	.001	<.001
Knows symptoms of plant diseases	42 (73.7)	41 (87.2)	.087	63 (64.3)	83 (90.2)	<.001	28 (29.8)	68 (76.4)	<.001	<.001	.043
Knows that red label means most toxic	37 (64.9)	40 (85.1)	.001	57 (58.2)	70 (76.1)	<.001	22 (23.4)	47 (52.8)	<.001	.122	<.001
Knows that green label means least toxic	22 (38.6)	31 (66)	.005	30 (30.6)	61 (66.3)	<.001	72 (28.9)	31 (34.8)	.043	.067	<.001
Knows some beneficial insects	22 (38.6)	38 (80.9)	<.001	39 (39.8)	65 (70.7)	<.001	25 (26.6)	41 (46.1)	.006	.089	<.001
Knows some banned pesticides in Nepal	17 (29.8)	12 (25.5)	.627	30 (30.6)	24 (26.1)	.569	12 (12.8)	10 (11.2)	.489	.007	.021
Knows about IPM methods	31 (54.4)	42 (89.4)	<.001	38 (38.8)	61 (66.3)	<.001	11 (11.7)	18 (20.2)	.115	<.001	<.001
Knows some alternative methods to pesticides	29 (59.9)	32 (68.1)	.076	51 (52)	54 (58.7)	.357	22 (23.4)	37 (41.6)	.009	<.001	.002
Knows some benefits of choosing alternatives	28 (49.1)	33 (70.2)	.030	49 (50)	39 (42.9)	.325	39 (41.5)	39 (44.3)	.700	.301	.012
Knows waiting period after spraying till harvest	40 (70.2)	30 (63.8)	.492	55 (56.1)	43 (46.7)	.196	45 (47.9)	34 (38.1)	.187	.008	.006
Knows to use PPE	45 (78.9)	46 (97.9)	.004	69 (70.4)	80 (87)	.006	65 (69.1)	73 (82)	.043	.225	.011
Significant positive differences			*9*			*6*			*8*	*9*	*14*

Abbreviations: IPM, Integrated Pest Management; PPE, personal protective equipment.

Table 3. Practice when handling pesticides and alternatives among farmers seen in 26 variables compared at baseline and endline (Pearson χ^2 test and linear-by-linear association, significant positive differences marked with gray, significant negative differences marked with red).

PRACTICE VARIABLES	TRAINED FARMERS			FELLOW FARMERS			CONTROL FARMERS			BASELINE	ENDLINE
	BASELINE (N = 57) NO. (%)	ENDLINE (N = 47) NO. (%)	*P* VALUE	BASELINE (N = 98) NO. (%)	ENDLINE (N = 92) NO. (%)	*P* VALUE	BASELINE (N = 94) NO. (%)	ENDLINE (N = 89) NO. (%)	*P* VALUE	LINEAR-BY-LINEAR ASSOCIATION, *P* VALUE	LINEAR-BY-LINEAR ASSOCIATION, *P* VALUE
Uses botanical pesticides	10 (17.5)	24 (51.1)	<.001	17 (17.3)	25 (27.2)	.103	7 (7.4)	8 (9)	.704	.052	<.001
Uses biopesticides	10 (17.5)	12 (25.5)	.321	13 (13.3)	20 (21.7)	.123	3 (3.2)	13 (14.6)	.006	.003	.107
Uses pheromone traps	0	11 (23.2)	<.001	0	17 (18.5)	<.001	0	6 (6.7)	.010	1	.005
Uses gloves when handling pesticides	13 (22.8)	43 (91.5)	<.001	22 (22.4)	56 (60.9)	<.001	21 (22.3)	28 (31.5)	.164	.949	<.001
Uses boots when handling pesticides	14 (26.1)	38 (80.9)	<.001	19 (19.4)	47 (51.1)	<.001	15 (16)	25 (28.1)	.047	.198	<.001
Uses mask when handling pesticides	38 (66.7)	44 (93.6)	.001	65 (66.3)	76 (82.6)	.010	62 (66)	73 (82)	.014	.928	.109
Uses protective overall when handling pesticides	4 (7)	31 (66)	<.001	6 (6.1)	29 (31.5)	<.001	4 (4.3)	11 (12.4)	.046	.455	<.001
Not entering new sprayed field	35 (61.4)	41 (87.2)	.003	66 (67.3)	82 (89.1)	<.001	60 (63.8)	76 (85.4)	.001	.852	.661
Takes notion on wind direction when spraying	43 (75.4)	42 (89.4)	.067	67 (68.4)	74 (80.4)	.057	56 (59.6)	73 (82)	.001	.041	.372
Backward walking when spraying	19 (33.3)	28 (59.6)	.007	32 (32.7)	50 (54.3)	.003	33 (35.1)	50 (56.2)	.004	.791	.779
Bathing after spraying	51 (89.5)	45 (95.7)	.232	87 (88.8)	84 (91.3)	.561	84 (89.4)	80 (89.9)	.907	.997	.265
Changing clothes after spraying	52 (91.2)	43 (91.5)	.962	90 (91.8)	88 (95.7)	.280	77 (81.9)	76 (85.4)	.525	.055	.118
Uses recommended pesticide dose	43 (75.4)	44 (93.6)	.013	63 (64.3)	80 (87)	<.001	78 (83)	81 (91)	.108	.149	.823
Reads pesticide label	37 (64.9)	40 (85.1)	.019	57 (58.2)	67 (72.8)	.034	49 (52.1)	58 (65.2)	.074	.122	.015
Reads expiry date	32 (56.1)	36 (76.6)	.029	53 (54.1)	64 (69.6)	.028	48 (51.1)	46 (51.7)	.933	.533	.002
Checks danger sign	28 (49.1)	33 (70.2)	.030	43 (43.9)	47 (51.1)	.320	31 (33)	41 (46.1)	.070	.041	.012
Reads instructions for use	25 (43.9)	22 (46.8)	.764	39 (39.8)	34 (37)	.688	20 (30.9)	25 (28.1)	.682	.093	.028
Does not open obstructed nozzle by blowing	53 (93)	34 (72.3)	.005	90 (91.8)	58 (63)	<.001	89 (94.7)	54 (60.7)	<.001	.617	.206
Uses brush and water to open obstructed nozzle	31 (54.4)	21 (44.7)	.325	64 (65.3)	42 (45.7)	.006	56 (59.6)	28 (31.5)	<.001	.664	.079
Determines dose by reading pesticide label	20 (35.1)	23 (48.9)	.154	35 (35.7)	18 (19.6)	.013	19 (20.2)	15 (17)	.584	0.030	<.001
Cleaning sprayer after use	29 (50.9)	46 (97.9)	<.001	49 (50)	85 (92.4)	<.001	50 (53.2)	86 (97.7)	<.001	.743	.729
Does not clean sprayer in river/lake/canal	21 (36.8)	40 (85.1)	<.001	30 (30.6)	77 (83.7)	<.001	45 (47.9)	79 (88.8)	<.001	.098	.463
Does not mix pesticides close by river/lake/canal	43 (75.4)	33 (70.2)	.550	69 (70.4)	69 (75)	0.478	67 (71.3)	58 (65.2)	.375	.632	.389
Does not spray when raining	20 (35.1)	44 (93.6)	<.001	23 (23.5)	85 (92.4)	<.001	27 (28.7)	82 (92.1)	<.001	.531	.771
Does not spray in windy conditions	16 (28.1)	43 (91.5)	<.001	18 (18.4)	85 (92.4)	<.001	19 (20.2)	74 (83.1)	<.001	.324	.085
Adjusts nozzle before spraying	20 (35.1)	20 (42.6)	.436	41 (41.8)	31 (33.7)	.248	48 (51.1)	44 (49.4)	.826	.049	.245
Significant positive differences			*16*			*14*			*12*	*5*	*10*

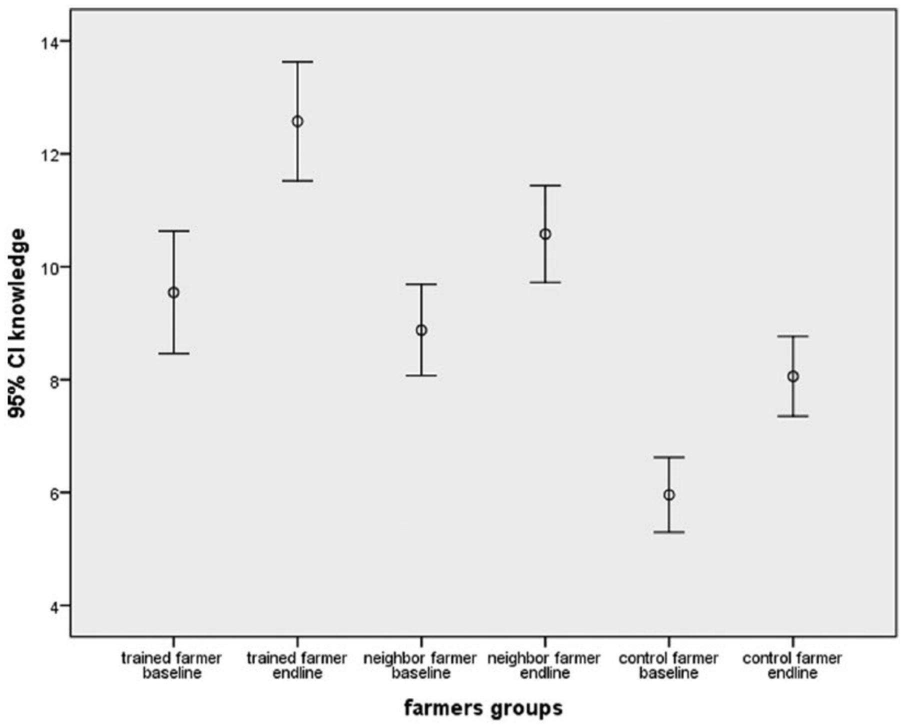

Figure 3. Aggregated knowledge and attitude scores among the 3 farmer groups, at baseline and endline (maximum score of 16; 1-way analysis of variance). CI indicates confidence interval.

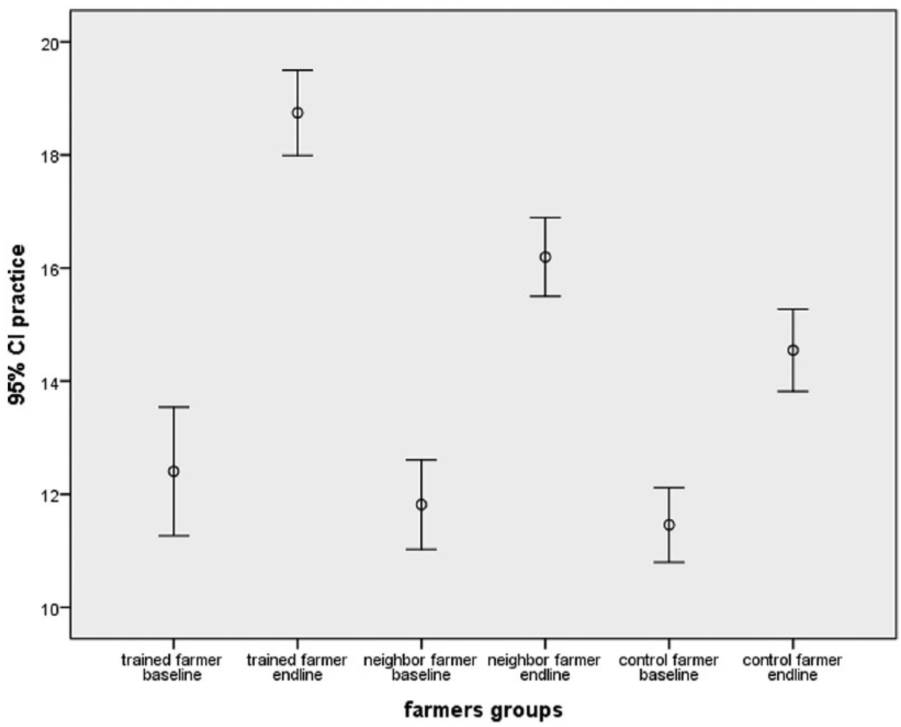

Figure 4. Aggregated practice score among the 3 farmer groups, at baseline and endline variable (maximum score of 26; 1-way ANOVA). CI indicates confidence interval.

in their knowledge and pesticide handling practice has been consistently shown in various studies.[23-33]

By training a group of farmers through FFS, we expected "dissemination of knowledge" into their neighboring farmers as well. Indeed, past studies report mixed outcomes regarding dissemination with many of them conveying possible dissemination,[34-37] whereas others did not find any significant dissemination.[25,27,32,33,38] Our follow-up study saw improvements in knowledge of neighboring farmers similar to the trained farmers, but less change was noted when it came to the

Table 4. Odds ratios for a high score in the aggregated variables on knowledge and practice among the 3 farmer groups at baseline and at endline (logistic regression analysis controlled for age, sex, education, and size of arable land).

FARMER	KNOWLEDGE AND ATTITUDE		PRACTICE	
	BASELINE	ENDLINE	BASELINE	ENDLINE
	ODDS RATIOS (95% CI)	ODDS RATIOS (95% CI)	ODDS RATIOS (95% CI)	ODDS RATIOS (95% CI)
Trained	16.67 (6.85–42.20)	9.85 (3.97–24.45)	2.62 (1.08–6.34)	13.05 (2.02–16.21)
Neighbor	2.77 (1.34–5.73)	3.01 (1.24–7.31)	1.58 (0.67–3.57)	5.71 (2.01–16.21)
Control	—	—	—	—

Abbreviation: CI, confidence interval.

Table 5. Knowledge of pesticide dealers on pesticides.

	BASELINE (N=24)	ENDLINE (N=23)	*P* VALUE
	NO. (%)	NO. (%)	
Familiarity with Nepal's pesticide act	17 (70.8)	20 (87.0)	.28
Knowledge on banned pesticides	17 (70.8)	22 (95.7)	.04
Knowledge on color code of highly toxic pesticides	17 (70.8)	22 (95.7)	.04
Knowledge on color code of least toxic pesticides	11 (45.8)	17 (73.9)	.07
Knowledge on adverse effects of pesticides on human health	18 (75.0)	23 (100.0)	.02

Table 6. Pesticide handling by pesticide retailers before and after intervention.

	BASELINE (N=24)	ENDLINE (N=23)	*P* VALUE
	NO. (%)	NO. (%)	
Selling pesticides			
Use any PPE while selling pesticide	17 (70.8)	15 (65.2)	.7
Selling any PPE	13 (54.2)	14 (60.9)	.7
Pesticide repackaging/mixing in shop	0 (0.0)	0 (0.0)	—
Inform farmers about pesticide label	24 (100.0)	23 (100.0)	—
Counseling farmers	22 (91.7)	23 (100.0)	.48
Selling botanical pesticides	6 (25.0)	8 (34.8)	.53
Selling organic pesticides	10 (41.7)	2 (8.7)	.017
Selling insect pheromones/attractants	3 (12.5)	7 (30.4)	.168
Selling of unregistered pesticides	14 (58.3)	0 (0.0)	<.001
Hygienic practices while handling pesticides			
Washing hands immediately after pesticide handling	14 (58.3)	19 (82.6)	.11
Handwashing before eating after handling pesticides	21 (87.5)	20 (87.0)	1.0
Not smoking or chewing tobacco before hand washing	22 (91.7)	20 (87.0)	.66
Bathing after the completing shop work	19 (79.2)	20 (87.0)	.71
Changing clothes after shop work before going home	18 (75.0)	19 (82.6)	.72

Abbreviation: PPE, personal protective equipment.

improvement of their practice. It is our experience that the major facilitators for dissemination from trained to neighboring farmers included personal qualities such as leadership quality and enthusiasm of the trained farmers. Factors that diminished transfer of knowledge were mostly related to neighboring farmers, eg, seeking financial benefit from the project, disinterest toward learning, not receiving PPE as the trained farmers did, difference in socioeconomic status from the trained farmers. Factors related to the trained farmers, such as lack of enthusiasm and inadequate teaching skills as witnessed by the project staff during their monitoring visits, also affected effective dissemination. In fact, such barriers in transferring farmer-to-farmer knowledge have been discussed in other similar settings such as in Indonesia,[33] Vietnam,[39] Zimbabwe,[31] and various African countries.[40]

Because our study was done within a development project rather than a research project, it had some shortcomings from a research perspective, an issue already well recognized.[41] Unlike in a well-randomized trial, the 3 categories of farmers in our study were dissimilar right from the beginning in various aspects. For example, there was more gender equality among the trained farmers because the project had urged the villagers to balance the genders going for the training courses. Likewise, the difference in landholding was expected because those who are selected for such voluntary courses are often better off, people have more trust in them, and they have a certain respect in the society. Unlike the control farmers, almost all the trained farmers and their neighboring farmers were members of cooperatives because they were accessed through the farming cooperatives. Such dissimilarities among the different groups of farmers have been reported in other studies as well.[24,25,27,33]

The background differences in the farmers are reflected in the baseline knowledge and attitude assessment as well. As a higher proportion of the trained key farmers and neighboring farmers belonged to a cooperative and had already received some training on pesticide use, they had better knowledge on more variables than the control farmers. One of the advantages of belonging to a cooperative as mentioned by the farmers is the support on equipment and training they get. Another explanation is that when the farmers among themselves choose a person to go for trainings, they often choose the better educated farmers, as seen in other surveys.[5,14] Furthermore, there was greater improvement in knowledge and attitude among the trained farmers, which can be attributed to the training. Higher improvement among the control farmers than neighboring farmers could be due to the lower knowledge level from the outset with more room for improvement in this group of farmers, as observed in other studies as well.[27,42]

Regarding safety practices, improvement was noted in all 3 categories of farmers. The reason for most improvement in the trained group is probably the training, and knowledge could have been passed on to the neighboring farmers as they improved the second most. The improvement among the control group could be due to 2 reasons. First, it is likely that knowledge had been disseminated from the project, as the control villages were not far away from the intervention villages.[26,43] Second, a general raise of knowledge level is likely to be occurring among the farmers as Chitwan has been receiving IPM training by government[44] and other nongovernmental agencies.[45] Also, several district-wide campaigns on safer pesticide use and alternatives were conducted during the project period. In addition, most farmers, irrespective of whether the farmers belonged to intervention or control villages, get their advice from the pesticide dealers many of whom were trained by the project to provide proper advice to them. Hence, influence on both intervention and control villages from other IPM activities cannot be ruled out. But as the effect of such external influence would be more or less equal in both intervention and control villages, the additional improvement in pesticide knowledge and practice among the trained farmers can probably be well credited to our intervention.

Besides the farmers, our intervention led to an increased level of knowledge among the pesticide retailers improving their knowledge about banned pesticides, color codes used in pesticide containers, toxicity levels of different pesticides, and their adverse health effects. Another important impact of the intervention was that unlike in the baseline, none of the retailers were selling unregistered pesticides at follow-up. They had better hygienic and counseling practices and improved their sale of PPE. Many of the changes were not significant, though, probably due only to their small number. Especially, in the low-income country settings, many pesticide retailers have low knowledge of pesticides[46] and are prone to professional misconducts,[47] and more importantly, they are often a major source of information for the farmers.[48] Indeed, pesticide retailers themselves are at a higher risk of pesticide toxicity.[16,49] Hence, enhancing their perceptions and practice through such trainings can indeed be valuable adjunct to rational use of pesticide in farming.[50] Intervening retailers along with the farmers have been shown to be effective in other settings as well.[51]

There were convincing grounds for us to purposively select the Chitwan District of the 75 districts of Nepal for our project. There is intensive vegetable cultivation and also because pesticide use in widely prevalent. Chitwan was largely an uncultivated dense forest before the Nepal government started spraying DDT for the Malaria Eradication Project in 1950s.[52-54] Immediately after control of malaria, Chitwan became a major farming region, and services and infrastructure expanded across the area.[55] Agriculture has been the primary source of income for 75% of the population in the district. Of the total 46 894 hectares of arable land, 44 291 hectares is used for agricultural purpose, of which about 6300 hectares is used for commercial vegetable production.[55] It is one of the highest vegetable growing districts of Nepal.[56] According to the District Agriculture Office, there are 4000 to 5000 persons actively working as commercial vegetable farmers.[55] Thus, Chitwan was probably the best site for implementing our intervention project.

Nonetheless, our project had several limitations. Because of various logistic problems, not all the participants in the baseline could be interviewed in the follow-up and we had to interview another agro-active member of the same family if they were available and willing to participate. Such loss to follow-up is common in community interventions of long durations as the participants change profession, migrate, or die. Follow-up is particularly difficult in developing countries because of a weak civil registry and difficulties in reaching the households.[22,57]

Apart from the unintentional selection bias of the farmers mentioned earlier, the villages also were not randomly selected. Low sample size, particularly of the pesticide retailers, may also have affected interpretation of our findings. Furthermore, possibility of recall bias while recalling symptoms cannot be ruled out as the trained farmers were more likely to recognize and remember any symptom related to pesticide poisoning than those who were not trained.[22] Thus, considering sample size and sampling, and possible biases, the results of the study have to be taken cautiously. In addition, although there was intention of influencing positive policy changes, the project could not effectively achieve this important goal. Indeed, to yield larger countrywide benefits, multipronged approached that incorporated policy changes would definitely have been desirable.[58] Also, we did not explore gender perspectives on pesticides in our study, which can be an important dimension especially to tailor gender-sensitive programs.[59]

Conclusions

Training of farmers seems to improve their knowledge and practice when handling pesticides as well as that of their fellow farmers. The training of pesticide dealers also seemed to have improved their performance also when it comes to counseling farmers. On this background, an improved extension service to farmers is recommended. However, we noted some bottlenecks such as market dynamics, availability of PPE, and the lack of alternative means of pest control on the markets that hindered transformation of knowledge into practice.

Acknowledgements

The authors would like to acknowledge the contributions made by all the stakeholders including the respondents (key, fellow, and control farmers and pesticide retailers). They highly appreciate the contributions made by the members of the Central Steering Committee and District Advisory Committee of the FHEN project. They thank the local cooperative bodies and IPM coordinators for their support to the project. In addition, they are thankful to Professor Dr Shree Krishna Giri for his contribution as the Project Coordinator during the initial period of the project. Finally, they thank all the staffs and members of Nepal Public Health Foundation. They sincerely acknowledge the technical assistance of the International Center for Occupational, Environmental and Public Health (ICOEPH) and Dialogos.

Author Contributions

EJ, BRP, DG, ST, and AV conceived and designed the experiments; agree with manuscript results and conclusions; and made critical revisions and approved final version. DG, AV, and EJ analyzed the data and jointly developed the structure and arguments for the paper. AV and DG wrote the first draft of the manuscript. DG, EJ, BRP, and ST contributed to the writing of the manuscript. All authors reviewed and approved the final manuscript.

REFERENCES

1. Aktar MW, Sengupta D, Chowdhury A. Impact of pesticides use in agriculture: their benefits and hazards. *Interdiscip Toxicol*. 2009;2:1–12.
2. Damalas CA, Eleftherohorinos IG. Pesticide exposure, safety issues, and risk assessment indicators. *Int J Environ Res Public Health*. 2011;8:1402–1419.
3. Konradsen F, van der Hoek W, Cole DC. Reducing acute poisonings in developing countries—options for restricting the availability of pesticides. *Toxicology*. 2003;192:249–261.
4. Mekonnen Y, Agonafir T. Pesticide sprayers' knowledge, attitude and practice of pesticide use on agricultural farms of Ethiopia. *Occup Med (Lond)*. 2002;52:311–315.
5. Jørs E, Morant RC, Aguilar GC, et al. Occupational pesticide intoxications among farmers in Bolivia: a cross-sectional study. *Environ Health*. 2006;5:1–9.
6. Jeyaratnam J. Acute pesticide poisoning: a major global health problem. *World Health Stat Q*. 1990;43:139–144.
7. Gunnell D, Eddleston M. Suicide by intentional ingestion of pesticides: a continuing tragedy in developing countries. *Int J Epidemiol*. 2003;32:902–909.
8. Calvert GM, Plate DK, Das R, et al. Acute occupational pesticide-related illness in the US, 1998–1999: surveillance findings from the SENSOR-pesticides program. *Am J Ind Med*. 2004;45:14–23.
9. Sharma DR, Thapa RB, Manandhar HK, Shrestha SM, Pradhan SB. Use of pesticides in Nepal and impacts on human health and environment. *J Agr Environ*. 2013;13:67–74.
10. Palikhe B. Challenges and options of pesticide use: in the context of Nepal. *Landschaftsökol Umweltforschung*. 2002;38:130–141.
11. 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;13:98.
12. Atreya K, Sitaula BK, Overgaard H, Bajracharya RM, Sharma S. Knowledge, attitude and practices of pesticide use and acetylcholinesterase depression among farm workers in Nepal. *Int J Environ Health Res*. 2012;22:401–415.
13. Pesticide Registration and Management Division, Ministry of Agriculture and Cooperative Government of Nepal. *A Handbook of Pesticide Statistics*. Kathmandu, Nepal: Ministry of Agriculture and Cooperative; 2010;.
14. GC YD. Status of pesticide use in Nepal and future strategy for their safe and alternative uses. https://www.scribd.com/document/264196800/Status-of-Pestiside-Nepal. Accessed November 2, 2016.
15. Diwakar J, Prasai T, Pant SR, Jayana BL. Study on major pesticides and fertilizers used in Nepal. *Scientific World*. 2008;6:76–80.
16. Lekei EE, Ngowi AV, London L. Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. *BMC Public Health*. 2014;14:389.
17. Oesterlund AH, Thomsen JF, Sekimpi DK, Maziina J, Racheal A, Jørs E. Pesticide knowledge, practice and attitude and how it affects the health of small-scale farmers in Uganda: a cross-sectional study. *Afr Health Sci*. 2014;14:420–433.
18. Shrestha P, Koirala P, Tamrakar AS. Knowledge, practice and use of pesticides among commercial vegetable growers of Dhading District, Nepal. *J Agr Environ*. 2010;11:95–100.
19. Neupane FP. Status of botanical pesticides in Nepal. In: Neupane FP ed., *Integrated Pest Management in Nepal. Proceedings of a National Seminar*. Kathmandu, Nepal: Himalayan Resource Institute; 2003:77–96.
20. Yadav BP. Review of vegetable IPM activities through farmers' field school (FFS) in Nepal. IV International Symposium on Horticultural Education, Extension and Training. *ISHS Acta Horticul*. 2004;67:760–764.
21. Atreya K, Johnsen FH, Sitaula BK. Health and environmental costs of pesticide use in vegetable farming in Nepal. *Environ Dev Sustain*. 2012;14:477–493.

22. Jørs E, Konradsen F, Huici O, Morant RC, Volk J, Lander F. Impact of training Bolivian farmers on integrated pest management and diffusion of knowledge to neighboring farmers. *J Agromedicine*. 2016;21:200–208.
23. Pontius J, Dilts R, Bartlett A. From farmer field school to community IPM: ten years of IPM training in Asia. RAP/2002/15. FAO Community IPM Programme, FAO Regional Office for Asia and the Pacific; 2002:1–106. ftp://ftp.fao.org/docrep/fao/005/ac834e/ac834e00.pdf.
24. Tripp R, Wijeratne M, Piyadasa HV. What should we expect from farmers field schools? A Sri Lanka case study. *World Dev*. 2005;33:1705–1720.
25. Ortiz O, Garrett KA, Heath JJ, Orrego R, Nelson RJ. Management of potato late blight in the Peruvian highlands: evaluating the benefits of farmer field schools and farmer participatory research. *Plant Dis*. 2004;88:565–571.
26. Orozco FA, Cole DC, Selahadin I, Wanigaratne S. Health promotion outcomes associated with a community-based program to reduce pesticide-related risks among small farm households. *Health Promot Int*. 2011;4:432–446.
27. Rola AC, Jamias SB, Quizon JB. Do farmer field school graduates retain and share what they learn? An investigation in Iloilo, Philippines. *J Int Agr Ext Educ*. 2002;9:65–76.
28. Huan NH, Mai V, Escalada MM, Heong KL. Changes in rice farmers' pest management in the Mekong Delta, Vietnam. *Crop Prot*. 1999;18:557–563.
29. Mancini F, Jiggins JL, O'Malley M. Reducing the incidence of acute pesticide poisoning by educating farmers on integrated pest management in South India. *Int J Occup Med Environ Health*. 2009;15:143–151.
30. Dipanah G, Mirdamadi M, Badragheh A, Sinaki SM, Aboeye F. Analysis of effect of farmer field school approach on adoption of biological control on rice producer' producer' characteristics in Iran. *Am-Eurasian J Agri and Environ Sci*. 2010;7:247–254.
31. Mutandwa E, Mpangwa JF. An assessment of the impact of FFS on IPM dissemination and use: evidence from smallholder cotton farmers in the Lowveld area of Zimbabwe. *J Sustain Dev Africa*. 2004;6:2.
32. Bentley JW, Barea O, Priou S, Equise H, Thicle G. Comparing farmers field schools, community workshops, and radio: teaching Bolivian farmers about bacterial wilt of potato. *J Int Agr Ext Educ*. 2004;14:45–61.
33. Feder G, Murgai R, Quizon JB. The acquisition and diffusion of knowledge: the case of pest management training in farmer field schools, Indonesia. *J Agric Econ*. 2004;55:221–243.
34. Hruska AJ, Corriols M. The impact of training in integrated pest management among Nicaraguan maize farmers: increased net returns and reduced health risk. *Int J OccupMed Environ Health*. 2002;8:191–200.
35. Ooi AC P, Praneetvatakul S, Waibel H, Walter-Echols G. *The Impact of the FAOEU IPM Programme for Cotton in Asia*. Hannover, Germany: University of Hannover; Uni Druck.
36. Yamazaki S, Resosudarmo BP. Does sending farmers back to school have an impact? a spatial econometric approach. Division of Economics, Research School of Pacific and Asian Studies. *Australian National University;* 2007. https://crawford.anu.edu.au/acde/publications/publish/papers/wp2007/wp-econ-2007-03.pdf.
37. Mauceri M, Alwang J, Norton G, Barrera V. Effectiveness of integrated pest management dissemination techniques: a case study of potato farmers in Carchi, Ecuador. *J Agri Appl Eco*. 2007;39:765–780.
38. Waddington H, White H. *Farmer Field Schools: From Agricultural Extension to Adult Education, 3ie Systematic Review Summary 1*. London, England: International Initiative for Impact Evaluation (3ie); 2014.
39. Rejesus RM, Palis FG, Lapitan AV, Chi TTN, Hossain M. The impact of integrated pest management information dissemination methods on insecticide use and efficiency: evidence from rice producers in South Vietnam. *Appl Econ Perspect Policy*. 2009;31:814–833.
40. Anandajayasekeram P, Davis KE, Workneh S. Farmer field schools: an alternative to existing extension systems? Experience from Eastern and Southern Africa. *J Int Agric Exten Educ*. 2007;14:81–93.
41. Sherwood S, Cole D, Crissman C. Cultural encounters: learning from cross-disciplinary science and development practice in ecosystem health. *Dev Pract*. 2007;17:179–195.
42. Feder G, Murgai R, Quizon JB. Sending farmers back to school: the impact of farmer field schools in Indonesia. *Appl Econ Perspect Policy*. 2004;26:45–62.
43. Kim J, Arrandale VH, Kudla I, Mardell K, Lougheed D, Holness DL. Educational intervention among farmers in a community health care setting. *Occup Med*. 2012;62:458–461.
44. Project for Agriculture Commercialization and Trade, Ministry of Agriculture Development, Government of Nepal. Micro grant Subprojects 2016. http://pact.gov.np/?option=grants&page=category&category=Sub%20Projects. Accessed February 12, 2017.
45. Bhattarai A, GC YD. Effectiveness of farmer field school (FFS) program in adoption of IPM Technology in Chitwan District, Nepal. *Agr Develop J*. 2015;11:1–12.
46. Lekei EE, Ngowi AV, London L. Pesticide retailers' knowledge and handling practices in selected towns of Tanzania. *Environ Health*. 2014;13:79.
47. Jallow MF, Awadh DG, Albaho MS, Devi VY, Thomas BM. Pesticide knowledge and safety practices among farm workers in Kuwait: results of a survey. *Int J Environ Res Public Health*. 2017;24:14.
48. Jin J, Wang W, He R, Gong H. Pesticide use and risk perceptions among small-scale farmers in Anqiu County, China. *Int J Environ Res Public Health*. 2017;14:29.
49. Rojas-García AE, Medina-Díaz IM, Robledo-Marenco Mde L, et al. Hematological, biochemical effects, and self-reported symptoms in pesticide retailers. *J Occup Environ Med*. 2011;53:517–521.
50. World Health Organization and International Association of Suicide Prevention. Safer access to pesticides: community interventions. http://www.who.int/mental_health/prevention/suicide/pesticides_safer_access.pdf. Accessed May 21, 2017.
51. Nafees M, Jan MR, Khan H. Pesticide use in Swat Valley, Pakistan: exploring remedial measures to mitigate environmental and socioeconomic impacts. *Mt Res Dev*. 2008;28:201–204.
52. Yabiku ST, Schlabach S. Social change and the relationships between education and employment. *Popul Res Policy Rev*. 2009;28:533–549.
53. Axinn WG, Yabiku ST. Social change, the social organization or families, and fertility limitation. *Am J Sociol*. 2001;106:1219–1261.
54. Shivakoti GP, Axinn WG, Bhandari P, Chehetri NB. The impact of community context on land use in an agricultural society. *Popul Environ*. 1999;20:191–213.
55. District Agriculture Development Office, Chitwan. District Agriculture Office. http://www.dadochitwan.gov.np/. Accessed November 4, 2016.
56. Agribusiness Promotion and Statistics Division Ministry of Agricultural Development Government of Nepal. *Statistical Information on Nepalese Agriculture 2012/13*. Kathmandu, Nepal: Government of Nepal; 2013.
57. Jørs E, Lander F, Huici O, Cervantes Morant R, Gulis G, Konradsen F. Do Bolivian small holder farmers improve and retain knowledge to reduce occupational pesticide poisonings after training on Integrated Pest Management? *Environ Health*. 2014;13:75.
58. Cole DC, Sherwood S, Crissman C, et al. Pesticides and health in highland Ecuadorian Potato production: assessing impacts and developing responses. *Int J Occup Environ Health*. 2002;8:182–190.
59. Atreya K. Pesticide use knowledge and practices: a gender differences in Nepal. *Environ Res*. 2007;104:305–311.