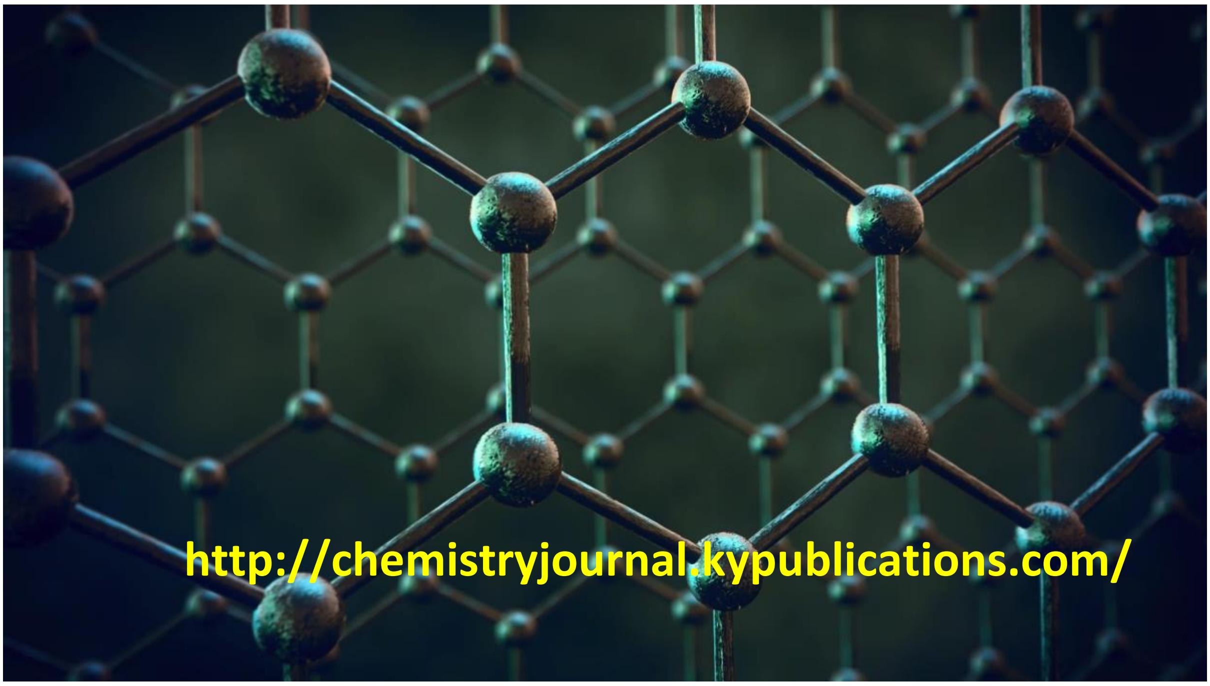

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Research Article

Self-Reported Symptoms of Acute Organophosphates Pesticide Poisoning in the selected agricultural zones of Guntur district-A Field Survey

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ABSTRACT
This study investigated inhalation exposure to organophosphate pesticides (OPP) and evaluated the associated health risks to vegetable growers living in the seven zones (Tenali, Bapaptla, Guntur, Mangalagiri, Pedavadlapudi, Narasaraopet, Macharla) of agricultural community of Guntur district, Andhra Pradesh. Study investigated pesticide exposure and its risk factors targeting vegetable farmers selected through cluster sampling. Samples were collected during 2014-15. . From results, it was concluded that different vegetables contain different concentration of pesticides means adsorption rate is different for each pesticide and vegetable. Blood cell acetylcholinesterase (AChE) activity was assessed using blood samples. The collection of biological samples was accompanied by a questionnaire-based survey on sociodemographic indicators, food consumption, and behavioral patterns. The results also indicate that the vegetable growers may be at risk for acute adverse effects via the inhalation of OPP during pesticide application, mixing, loading, and spraying. It is suggested that authorities and the community should implement appropriate strategies concerning risk reduction and risk management

Introduction

Agriculture has been one of the primary economic avenues in the India contributing to about 46% to the gross domestic product (GDP) [1]. Crops comprise about 76.2% of the total agricultural sector to the country's national income. To minimize crop damage and to increase land productivity, the use of pesticides has become more essential [2]. Occupational exposures to pesticides occur during the production, transportation, preparation and application of pesticides in the workplace. Exposure to pesticides is one of the most important occupational risks among farmers in developing countries [3].

Organophosphorus (OP) pesticides are of particular concern among the various pesticides because of their widespread use, both for residential and agricultural purposes, and because of their adverse effects on the nervous system[4]. Measurement of OPs to vegetable growers health has been documented in several reports, much effort is required to delineate the risk profile of OPs, including their toxic mechanisms[5].

Acute toxicity is normally the result of a single exposure and the symptoms are seen within a comparatively short time of exposure, usually within hours or days. Acute health effects may include irritation of skin or eyes or respiratory irritation. Organophosphates are associated with well-known acute health problems such as nausea, dizziness, vomiting, headaches, abdominal pain, and skin and eye problems [6] At present, India is the largest producer of pesticides in Asia and ranks twelfth in the world for the use of pesticides with an annual production of 90,000 tons[7]. A vast majority of the population in India is engaged in agriculture and is therefore exposed to the pesticides used in agriculture.[8]

In developing countries including India, agricultural workers who are engaged in the occupation of spraying pesticides in crops get the direct exposure of pesticides due to unsafe and non-preventive work practices. They do not use the Personal Protective Equipments (PPE) like safety masks, gloves etc. during the aerial spraying of pesticides resulting in the entry of pesticides in the blood stream via respiratory tract through inhalation which can adversely affect respiratory system. Pesticides being used in agricultural tracts are released into the environment and come into human contact directly or indirectly. Humans are exposed to pesticides found in environmental media (soil, water, air and food) by different routes of exposure such as inhalation, ingestion and dermal contact. Exposure to pesticides results in acute and chronic health problems. These range from temporary acute effects like irritation of eyes, excessive salivation to chronic diseases like cancer, reproductive and developmental disorders etc.[9]

Previously the health effects of acute pesticide poisoning among the cotton growers of India have been reported by Mancini et al., [10]. Earlier studies on the pesticide factory workers of Bhopal have demonstrated significant effects of organophosphate pesticides in human beings. Review literature indicates that and many researchers reported adverse effects of organophosphate pesticides in human pesticides vegitable growers and agricultural field workers. No other work is available in literatures hence the present study has been undertaken to investigate the indirect effects of hazardous organophosphate pesticides chlorpyrifos, diazinon, fenitrothion, Malathion, dichlorvos Monocrotophoson the farm sprayers of Guntur district selcted areas.

Farmers in the Guntur district are directly and indirectly exposed to OPP residues either by inhalation during mixing, loading, or application of pesticides; by ingestion through artesian well water; or by dermal exposure from contact with soil residues, pesticide residues on plants, or while handling pesticides. This study will focus on the inhalation route of organophosphate pesticides that is chlorpyrifos, dicrotophos etc., because they are the most popular and widely used in Guntur district agricultural area. Inhalation exposure results in the individual breathing in dilute pesticide, that is, absorbed through the surface of the lung. Chemicals then enter the blood stream and are distributed to the rest of the body [11].

Methods and Materials

This study was approved by the Ethical Review Committee for Research Involving Human Subjects. All participants signed a consent form prior to participation in this study. 127 vegetable growers (alost eaqual members each from seven zones) were selected as the study group. Vegetable growers were asked to participate in this study based on the farmers organophosphate pesticide use. The reference, or control, groups were made up of seventy workers who are do not work with pesticides. The reference area was chosen based on interviews and background data. Since they live in the same subdistrict as the vegetable growers, this study will also investigate whether the reference group has inhalation exposure at work to the specific pesticides used by the vegetable growers (Figure 1). Data gathering was done using the following: (1) questionnaire—structured personal interview with farm workers/farmers was done by research assistants who were trained prior to the data collection. Details included personal information, health history, pesticide usage, work practices, work conditions, risk factors associated with pesticide exposure, and health data; (2) exposure assessment monitoring on work conditions, work practices, and pesticide concentration; (3) work analysis in each farm was also done to validate work practices related to pesticide preparation and application. Recall bias was dealt with by confining the health data questionnaire to the last one year from the time of interview. The health data were also collected by medical doctors who simultaneously conducted physical assessment of the farmers. Data were encoded and analyzed using SPSS program. Statistical tools used were summary statistics, and Pearson correlation coefficient.

Figure 1 : Map showing study area (selected agri-zones in Guntur district)

Study area

Study was carried out, from July 2014-Decmber 2015, the farmer's fields of ten prominent places of Guntur district of Andhra Pradesh., i.e., surroundings fields of Tenali, Narakodur, Chebrolu, Mangalagiri, Pedavadlapudi, chiluvur, Bapatla, Narasaraopet, Repalle, Macharla etc villages & small cities. The subject area is located in the Krishna river, guntur district, Andhra Pradesh, India (Figure 1). The river has a watershed area of 6,000 km2 and three reservoirs.

Study methods

Field survey: Examinations were conducted in 2014-2015. During the examinations, anthropometric measurement, urine sampling, blood sampling, a health examination, and an interview using a questionnaire for socio-demographic characterization were conducted for formers in this order. The results of the anthropometric measurement and health examination were reported to parents on site.

Biological monitoring using blood and urine samples: Urine samples were used to evaluate exposure to pesticides. Single-spot urine samples collected during the health examination in the morning (9 to 11 A.M.) were immediately frozen with dry ice. The samples were brought to Guntur, and the major metabolites of various OP pesticides, chlorpyrifos, diazinon, fenitrothion, Malathion, dichlorvos, Monocrotophos were quantified by gas chromatography using a flame photometric detector (FPD-GC). Standard materials were purchased from Merck India co Ltd. Quality control data was used to provide an overall assessment of the precision, accuracy, and overall reliability of the method. Spike sample recoveries and urine blank analysis were conducted for every set of 9 samples. Pooled urine from a healthy volunteer not being treated with any drugs nor exposed to chemicals was used as blanks and for spike recoveries. At a concentration of 20 μg/L, the within-series imprecision (CV%) was 5.5% for diazinon, 8.7% for dichlorvos, 7.1% for Malathion, and 11.3% for fenitrothion (n=5). The between-day imprecision during 10 consecutive days was 8.0% for Monocrotophos, 6.1% for chlorpyrifos, 8.7% for diazinon, and 11.3% for diazinon. The mean recoveries within series and between days were 94.2 and 109.7% for diazinon, 100.6 and 105.7% for chlorpyrifos, 93.9 and 94.7% for fenitrothion, and 85.7 and 82.9% for chlorpyrifos & , respectively. The limit of detection (LOD) and quantitative limit were 1.0 and 2.0 μg/L for chlorpyrifos and 0.5 and 1.0 μg/L for diazinon, fenitrothion, fenitrothion, dichlorvos and Malathion, respectively, indicating similar or greater sensitivity to those in recent studies on urinary chlorpyrifos levels. Values below LOD were assigned a value of LOD/2. Total molar quantities (nmol/L) were calculated by combining individual chlorpyrifos for diazinon and fenitrothion separately. Creatinine concentration (μg per dl) was determined by the Jaffe method.

Blood was taken from the fingertip with a finger-prick device by one of the authors (Guntur Physician). Immediately after sampling, the levels of AChE activity and Hb were determined using a commercial kit (EQM Research, Inc., USA). The former has been used as an effect indicator for anticholinesterase agents such as organophosphates and carbamates.

Results

Urinary metabolites of organophosphorus pesticides

The major urinary metabolites of the OP pesticides, namely, CHLORPYRIFOS, DICHLORVOS, MONOCROTOPHOS, and DIAZINON, were determined by gas chromatography. All these major metabolites were detected in at least one sample (Table 2).Detection rates varied between the metabolic species, that is, CHLORPYRIFOS, DICHLORVOS, MONOCROTOPHOS, and DIAZINON were detected in 8.6, 21.7, 17.2, and 29.8% of the subjects, respectively (Table 2). The median levels of DIAZINON, DIAZINON and total FENITROTHION were 5.8, 3.1, and 11.8 nmol/L, respectively. Significant differences were found in terms of the detection rates among the communities, and Lotion 3 had the lowest detection rates and mean levels except for MONOCROTOPHOS, for which the rate was comparable to that of Location 2(Table 1).

Table 1: Detection and concentration of the metabolites of OP pesticides in urine

		Detected number (person)	Median	Mean	Percentiles				Maximum
					25th	50th	75th	95th	
CHLORPYRIFOS (μg/L)	Location 1: n=65	5	0.5	0.64	0.5	0.5	0.5	2.21	3.4
	Location 2:n=69	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Location 3:n=64	12	0.5	1.26	0.5	0.5	0.5	3.1	28.4
	All (n=198)	17	0.5	0.79	0.5	0.5	0.5	2.01	28.4
DICHLORVOS (μg/L)	Location 1: n=65	13	0.25	1.88	0.25	0.25	0.25	10.01	38.5
	Location 2: n=69	6	0.25	0.9	0.25	0.25	0.25	5.05	25.6
	Location 3:n=64	24	0.25	7.68	0.25	0.25	1.4	24.23	333.8
	All (n=198)	43	0.25	3.41	0.25	0.25	0.25	8.85	333.8
MONOCROTOPHOS (μg/L)	Location 1:n=65	19	0.25	0.54	0.25	0.25	0.88	1.47	2.5
	Location 2:n=69	8	0.25	0.39	0.25	0.25	0.25	1.5	3
	Location 3:n=64	7	0.25	0.62	0.25	0.25	0.25	0.75	20.4
	All n=198	34	0.25	0.51	0.25	0.25	0.25	1.4	20.4
Malathion(μg/L)	Location 1:n=65	17	0.25	0.69	0.25	0.25	0.75	2.81	9.7
	n=64	16	0.25	0.42	0.25	0.25	0.25	1.3	1.5
	n=64	26	0.25	2.57	0.25	0.25	0.75	6.63	113.2
	n=198	59	0.25	1.2	0.25	0.25	0.75	1.51	113.2
DIAZINON (nmol/L)	All (n=198)		5.77	30.5	5.77	5.77	5.77	76.1	2594.6
fenitrothion (nmol/L)	All (n=198)		3.11	10.5	3.11	3.11	7.55	18.85	671.5

Acetyl cholinesterase (AChE) activity in blood

AChE activity in the blood samples was within the expected range and a significant difference was observed regarding the AChE activities in the blood samples; that is, formers from Guntur zone (Narakodur, Chebrolu) (27.4±3.0 U/gHb) had lower values than those of the other two villages Names Pedavadlapudi, mangalagiri (28.7 ± 3.3 and 27.9 ± 3.6 U/gHb)

AChE levels were compared between detected and non-detected groups for CHLORPYRIFOS (n=46 and n=150 for detected and non-detected, respectively), MONOCROTOPHOS (n=79 and n=117 for detected and non-detected, respectively), and total FENITROTHION (n=100 and n=96 for detected and nondetected, respectively). Results showed that formers with detected levels of CHLORPYRIFOS had significantly lower AChE activity (27.2 ± 2.6 U/gHb) than the formers whose CHLORPYRIFOS levels were below the LOD (28.3 ± 3.5 U/gHb).

Sociodemographic Profile

The study included 140 males (70%) and 60 females (30%) with ages ranging from 16 to 72 (mean =47 years) showing a relatively adult population. Seventy one percent (71%) were married and majority were working as agricultural workers (82%), and the remaining were pesticide applicators, mixers, and loaders (18%). The respondents were living in their present address for an average of 41.21 years (SD =17.24) with a mean distance of 3.1 KM (SD = 3.7KM) from the vegetable plantation or farm.

Few farmers reported history of smoking (24.32%), and 12% claimed they smoked and 34% had a history of chewing tobacco. The average number of cigarettes and tobacco consumed in a week were 18 sticks and 4 tobacco, respectively.

Factors Related to Pesticide Exposure

The farmers used pesticides in their farms in an average of 1.9 days per week. The mean total application time was 3.47 hours (mean = 3.47±2.1). The mean amount of pesticide used in an application was 22.35 L per application (mean 23.±1.1). The farmers also reported that in an average year, there were 2.40 (mean =2.41±1) cropping seasons with a mean of 3.84 (mean =3.86±2.1) months per cropping season (Table 2).

Table 2: Mean pesticide exposure among vegetable farmers in Gunutr district.

Pesticide usage in farm	Mean	Standard deviation
Amount of pesticide (Liters) per application	**22.35**	**48.17**
Average of total application time (hrours) per day	**3.47**	**1.84**
Average amount of time used to prepare dilution (minutes) per application	**14.18**	**29.88**
Average spraying application per day	**2.76**	**3.6**
Days of pesticide use in a week	**1.9**	**1.23**
Months per cropping season	**3.84**	**0.75**
Cropping seasons per year	**2.3**	**0.53**

72% had spills while they were spraying, mixing and loading. 44.5% reported that they wiped their sweat with a contaminated piece of fabric, 41.7% re-entered recently sprayed area, 37.4% had exposure because of damaged backpack sprayer, and 31.8% were exposed when they sprayed against the wind (Table 3).

Table 3: Percentage distribution of work practices.

Risk factors	Frequency	Percentage (%)
Given instructions on how to use pesticide	156	73.9
Spills while spraying	152	72.0
Spills while mixing and loading	152	72.0

Wiping sweat on the face with a contaminated piece of fabric	94	44.5
Re-enter recently sprayed area	88	41.7
Damaged backpack sprayer	79	37.4
Spraying Against the wind	67	31.8
Eating at Worksite	11	5.2

One hundred seventy six or 88.4% reported that they wore protective equipment while working. However, further analysis shows that they did not frequently use such equipment nor had adequate gear to fully protect themselves. One hundred forty two or 67% never used coveralls. The same pattern was seen among all kinds of personal protective equipment (PPE) with the exception of boots which was frequently used by 77.5% of farmers.

Pesticide Exposure

94% said that they have worked with or used pesticides in their lifetime, and 16.4% from this population used pesticides in their own households. The vegetables commonly grown in the area were potatoes (67.4%), cabbage (63.7%), and carrots (36.8%).

Majority (87%) reported occupational exposure to pesticides during their farm work while 13% were exposed accidentally. The predominant form of exposure was liquid mist (56.5%). The most common route of pesticide entry in the study was respiratory (68.9%) followed by dermal and ocular entry (60.5% and 38%, resp.).

Majority of the respondents used pyrethroid (46.4%) in their agricultural work. 24.2% said they used organophosphates while 21.3% used carbamates.

Sumicidine was the most commonly used pyrethroid which contains fenvalerate as its active ingredient. Meanwhile, Methamidophos is an active ingredient in most organophosphate pesticides. Mancozeb is present in carbamates while cypermethrin is found in pyrethroids

Table 4 shows that 37% and almost 14.7% of the study population used pesticides with active ingredients of fenvalerate and cypermethrin, respectively. Both of these ingredients are classified by WHO as moderately dangerous. 24.2% of the farmers used methamidophos which is a highly dangerous formulation. 23.7% used mancozeb which is not dangerous under normal use.

Table 4

Pesticide classification	Active ingredient	WHO classification	Frequency	Percentage
Pyrethroid	Fenvalerate	II	78	37
	Cypermethrin	II	31	14.7
Organophosphate	Metamidophos	IB	51	24.2
Carbamates	Mancozeb	O	50	23.7

The pesticide exposure of the farmers measured in Table 5 as dependent variable was related to the amount of pesticide used in liters, frequency of use and duration of use. All the independent variables, except amount and years of pesticide use were categorical variables. Those who used more pesticides over a longer period of time had higher total pesticide exposure. Those who were exposed to fungicides and insecticides also had higher total pesticide exposure. Furthermore, a farmer who was a pesticide applicator, mixer, loader and who wiped sweat with contaminated piece of fabric, and who had not been given instructions through training association was at risk of having higher pesticide exposure.

Table 5: Bivariate Analysis between Total Pesticide Exposure and Certain Risk Factors. Correlation significant at P = .05 level.

Exposure factors	Pearson correlation coefficient (*P* value)
Amount of pesticide used (in liters)	.465 (.001)
Years of pesticide use	.247 (.003)
Wiping sweat with contaminated piece of fabric	.155 (.049)
Insecticides	.351 (.001)
Fungicides	.177 (.025)
Instructions given through trainings	.167 (.036)
Agricultural pesticide applicator/mixer/loader	.180 (.023)

Seventy four percent (74%) of the respondents became ill because of work for the last 12 months preceding the study. The most common symptoms were headache (64.1%), muscle pain (61.1%), cough (45.5%), weakness (42.4%), eye pain (39.9%), chest pain (37.4%), and eye redness (33.8%). These health symptoms were non-specific for pesticide exposures. A subsequent study is recommended to focus on adverse health effects of these farmers and association with certain risk factors.

Discussion

The urinary concentration of OP metabolites was examined to assess the exposure to OP pesticides in previous non-occupational exposure studies, particularly in developed countries. In most of these studies, however, the health effect of chronic exposure was not examined. Young et al. [12] examined the relationship between maternal OP urine metabolites and infant neuronal development using the Brazelton Neonatal Behavioral Assessment Scale for 381infants younger than 62 days of age. They found a significant association between increased total concentration of maternal urinary OP metabolites and increased numbers of abnormal reflexes in the infants. The exposure level in the present study was lower than that in these studies. The results of this study identified pesticide exposure and farming practices of farmers in the largest vegetable producing area in the Philippines. The poor PPE use was seen in this study. This has also been documented in other countries. In the study of Coble et al. in 2005 [13], and Thompson et al. in 2003 [14], poor usage of protective equipment increases pesticide residues accumulating in the body.

Organophosphates, carbamates and pyrethroid pesticides were the most commonly used type of pesticides among the farmers in this study. The same was seen in the study of Clarke et al. in 1997 in Ghanna where organophosphates consisted of the most commonly used pesticides followed by carbamates and organochlorines. The same trend was seen among farmers in Sri Lanka and in Brazil.

The farmers in this study used pesticides in their farms with a mean application time of 3.47 hours The mean amount of pesticide used in an application was 21.35 liters per application. The number of spray operations per week has been proven to have significant association with the likelihood of experiencing neurobehavioral, respiratory, or intestinal symptoms in a study among Indonesian farmers [15]. In a study among North Carolina growers and agents [16], it was found that the study population perceived that once the pesticide is diluted and reentry intervals are observed, the risk it poses becomes diminished.

On the other hand, other active ingredients like cypermethrin, mancozeb, and methamidophos have documented effects to humans. Skin sensations were reported to occur among field workers and usually lasted only for a few hours and did not persist for more than one day after exposure to cypermethrin. The study also showed certain risk factors associated with pesticide exposure such as re-entering recently sprayed area, spraying against the wind, use of damaged backpack sprayer, spills on the back, spills while mixing pesticides, among others. Aside from direct pesticide use, the different agricultural tasks mentioned above may also contribute as risk factors to pesticide exposure. There are many health symptoms associated with pesticide exposure. There is evidence that weight loss could be a possible health effect of chronic pesticide poisoning. Respiratory symptom such as coughing were also documented in this study. Senthilselvan et al. found a significant association between carbamate exposure and prevalence of asthma among those non-asthmatic farmers and lower mean lung function variables among those with asthma. This study has shown the pesticide exposure of farmers in the largest vegetable producing area in the Philippines. It is vital that a sequential exposure assessment be done in order to come up with a correlation study between pesticide exposure and health problems.

Conclusions

The study showed that pesticide use is prevalent among farmers in Guntur district which is the largest vegetable producer in Andhra Pradesh state, India. There were unsafe work practices that predisposed the farmers to health related problems. This study suggests that intervention measures be done to lower pesticide exposure of farmers. It is also suggested that chronic effects of pesticide cited in certain studies [17] such as carcinogenic effects, poor reproductive outcomes, neurologic and respiratory disorders, impairments of the immune system and birth defects should also be investigated in future studies.

This manuscript adds to existing literature on pesticide exposure in the Philippines which are so far mainly descriptive in nature. This paper also identifies risk factors such as work practices and designs of containers/sprayers that may increase pesticide exposure among farmers. This also calls for a local level policy research for program intervention among vegetable farmers using pesticides.This study provides the first biological monitoring data on exposure to OP pesticides in agricultural area of Guntur district. The concentration of urinary DIAZINON metabolites among rural Guntur district fomrers was lower than that reported in studies on formers in other agrizones like Tenali, Bapatla. A between-community difference was found in the urinary DIAZINON metabolite level, although the route of OP pesticide intake was not elucidated. More work is required to clarify the potential exposure routes and also to characterize the exposure level of other subgroups of the population such as adults, mother-child pairs, and father-child pairs.

Generally, the pesticides used incorrectly and unhealthy when preparing of spraying, and do not adhere to the recommended indications and contraindications. Unfortunately, most interviewees had only finished primary or preparatory school education, but no positive response for them was noticed regarding the negative effects of pesticides on health and routes of contamination with pesticides. For example, many of educated farmers read labels of pesticides containers but no or very rare taking precautions after coming in contact with pesticides. Finally, the study suggested that great efforts regarding pesticide management and regulations programs on safety precautions, reinforcement of safety behaviors, to reduce potential health risks and improve farmer awareness against pesticides application and its hazards should be implemented.

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