Journal of Exposure Science and Environmental Epidemiology (2010) 20, 196–204
© 2010 Nature Publishing Group All rights reserved 1559-0631/10/$32.00
www.nature.com/jes

Risk assessment of pesticide exposure on health of Pakistani tobacco farmers

DILSHAD AHMED KHAN, SAIRA SHABBIR, MAHWISH MAJID, TATHEER ALAM NAQVI AND FAROOQ AHMED KHAN

Department of Pathology, Army Medical College, NUST, Rawalpindi, Pakistan

Tobacco is an important cash crop of Pakistan. Pesticides are commonly used to increase the crop yield, but their health impact has not been studied yet. The objectives of the study were to determine the frequency of pesticide poisoning and to explore the knowledge, attitudes and practices (KAP) towards safety measures among the tobacco farmers in Swabi, Pakistan. One hundred and five tobacco farmers involved in pesticide application were randomly selected from two villages of district Swabi. A structured questionnaire was used for clinical and KAP information. Plasma cholinesterase (PChE) levels were measured by Ellman's method by using GD Italy kits. All tobacco farmers were males with a mean (SD) age of 26 (9) years. The majority of the farmers reported multiple symptoms headache, dizziness, vomiting, shortness of breath, muscle weakness and skin rash correlate with the clinically significant depression of PChE levels. Out of 105 pesticide applicators, 58 (55%) had post-exposure reduction in PChE levels $<20\%$ from baseline, 35 (33%) had mild poisoning (20–40% reduction) and 12 (11%) had moderate poisoning ($>40\%$ reduction). Most of the farmers did not use any personal protective equipment during pesticide handling. Only a few used shoes (31%), masks (14%) and gloves (9%) during pesticide spray. In conclusion, the tobacco farmers had mild to moderate pesticide poisoning, which was correlated with depression in PChE levels. Moreover, most farmers had little knowledge about the safety measures, casual attitude and unsatisfactory safety practices with regard to the use of basic protective equipments during pesticide applications on the tobacco crop.
Journal of Exposure Science and Environmental Epidemiology (2010) **20,** 196–204; doi:10.1038/jes.2009.13; published online 17 June 2009

Keywords: *pesticide, plasma cholinesterase, tobacco farmers, adverse health effects, protective equipment.*

Introduction

Pesticides are considered a vital component in maintaining high agricultural productivity in modern farming. Indiscriminate use and improper handling of pesticides in agriculture have caused serious health problems in many developing countries, which represent 30% of the global pesticide consumer market (Peres et al., 2006). Organophosphate (OP) and Carbamate (CM) insecticides are commonly used for spraying on the tobacco crops in Pakistan. Although pesticides have beneficial effects on the crop yield, insufficient protective measures to counter the harmful effects of pesticide is a major health issue in the tobacco growing areas. Farmers harvesting tobacco crop are more prone to adverse health effects of pesticides because frequent spraying is required on the broad and succulent tobacco leaves for pest control (McDaniel et al., 2005; Damalas et al., 2006).

1. Address all correspondence to: Dr. Dilshad Ahmed Khan, Department of Pathology, Army Medical College, Rawalpindi, Pakistan.
Tel.: +92 3005147938. Fax: +92 51 5529988.
E-mail. dilshad56@yahoo.com
Received 13 May 2008; accepted 8 December 2008; published online 17 June 2009

Acute pesticide poisoning is an illness or a health effect resulting from suspected or confirmed exposure to a pesticide within 48 h (WHO, 2008). Depending on the toxicity of the compound, dosage and exposure time, the symptoms of pesticide exposure vary from headache, vomiting, skin rash, respiratory problems and convulsions (Cornwall et al., 1995). Plasma cholinesterase (PChE) levels are more reliable indicators than the symptoms attributed to exposure, for risk assessment and monitoring of pesticide intoxication in farm workers (Dasgupta et al., 2007). Only a few studies have been carried out on the pesticide applicators in Pakistan. A high frequency of pesticide poisoning among cotton farmers (Khan et al., 2000) and fruit farm workers in Gadap, Karachi, have been reported because of inadequate safety practice (Azmi et al., 2006).

The tobacco farmers in Malaysia had high prevalence of pesticide toxicity owing to inadequate training, lack of use of protective clothing and improper storage of pesticides (Reeves and Schafer, 2003). A study conducted on Greek tobacco farmers also laid emphasis on the need for using personal protective equipment (PPE) to counteract the hazardous effects of pesticides (Damalas et al., 2006). The effects of pesticides on farmers' health and the common personal safety practices of farmers during pesticide handling have not been studied in Pakistan.

Tobacco is an important cash crop of our country, and approximately 73% of the total tobacco is cultivated in Swabi and Mardan districts of NWFP, Pakistan. An attempt has been made to determine the effects of pesticide use on tobacco farmers' health by monitoring the frequency of clinical symptoms and PChE levels among the pesticide applicators in district Swabi, Pakistan. In addition, we also assessed the knowledge, attitudes and safety practices adopted by the tobacco farmers in handling pesticides in the fields. This study will help in developing strategies for prevention and control of pesticide poisoning in our country.

Subjects and methods

Study Area

Tobacco, an important cash crop of Pakistan, is cultivated over an area of 46.6 thousand hectares with a production of 88.2 thousand tonnes in the NWFP province of Pakistan (Pakistan Tobacco Board, 2004). District Swabi of NWFP is famous for the production of the fine quality Flue-cured Virginia tobacco that is used for the manufacture of cigarettes. The area under tobacco crop in this district is about 12,601 hectares with a production of 30.1 thousand tones that is 47% of the total tobacco production in NWFP. The study was carried out in the two randomly selected villages; Chota Punjab and Jangen Nath located in district Swabi. Study protocol was approved by the Institutional review committee of Army Medical College, Rawalpindi, in accordance with the Declaration of Helsinki Principles and Higher Education Commission (HEC), Pakistan.

Subjects

A cross-sectional study design was used with a sample of 105 tobacco farmers involved in pesticide application during the crop season. Our research team surveyed district Swabi of NWFP province at the start of the tobacco growing season in March 2007. A total of 317 inhabitants, consisting of 128 from Chota Lahore and 189 from Jangen, were identified as tobacco farmers involved in pesticide application. The data were collected from the Union Council office of Chota Punjab and Jangen Nath, as well as from personal interviews. A total of 112 potential male pesticide sprayers were recruited after informed consent from Chota Lahore ($n = 45$) and Jangen Nath ($n = 67$) by a random draw using a list of pesticide applicators obtained from the Union Council offices.

All the participants were male full-time farmers involved in preparation, storage and spraying of the pesticides for 30 or more hours in a month. They were divided into small groups, and the adverse effects of pesticides on health were explained to them before the start of the study. A qualified medical doctor took the medical history, performed a medical examination of each potential participant and relevant routine investigations for screening of the potential participants in the rural health center. A total of seven farmers were excluded from the study. One patient of diabetes mellitus, one patient of hypertension and two cases of hepatitis C were excluded from the study. Two farmers did not give informed consent and one was lost during the post-spray period.

KAP Information

Data were collected by means of direct personal interviews conducted by our health team. The health team, comprising qualified doctors, a chemical pathologist, an industrial hygienist and a PhD student, conducted the survey in the months of May–June 2007. The doctors administered the structured questionnaire after obtaining informed consent and provided information on study objectives, procedures and implications to participants. Demographic information of each tobacco farmer was obtained. Farmers' knowledge regarding the health hazards of pesticides and safety-related variables were assessed.

The research team went to different tobacco fields and observed spraying and safety equipment practices for 1–2 h. Safety practices of the pesticide applicators employed during handling, storage and application of pesticides on the tobacco crop were noted. The team collected empty containers of pesticides from tobacco fields and canals. Pesticide labeling and storage conditions were also inspected.

The farmers used a total of six different types of pesticides. Categories of pesticide were scaled according to the WHO class description: Class 1, extremely hazardous (WHO class Ia) and highly hazardous (WHO class Ib); Class 2, moderately hazardous (WHO class II) and Class 3, slightly hazardous (WHO class III) (WHO, 2001). The information about the types of pesticide used was obtained from farmers, empty containers collected from the field and agricultural supply stores.

Clinical History and Medical Examination

Detailed clinical history and medical examination of each participant was carried out by a trained licensed physician within 1–4 h after spray at the farms on different days during the study period. The characteristic signs and symptoms of pesticide poisoning were recorded on a standard pictorial questionnaire (Figure 1).

Specimen Collection and Plasma Cholinesterase Analyses

Blood samples were collected twice in heparinized tubes for the measurement of PChE levels in pesticide applicators. Pre-exposure baseline PChE levels of the tobacco farmers were collected at the beginning of the crop season in the months of March–April 2007. Post spray PChE were collected in the months of May–June 2007 in the field. The plasma was separated by centrifugation at 1500 *g* for 10 min in the local rural center laboratory. The plasma samples were transported in dry ice to the clinical pathology laboratory of Army Medical College, Rawalpindi, within 8 h after collection.

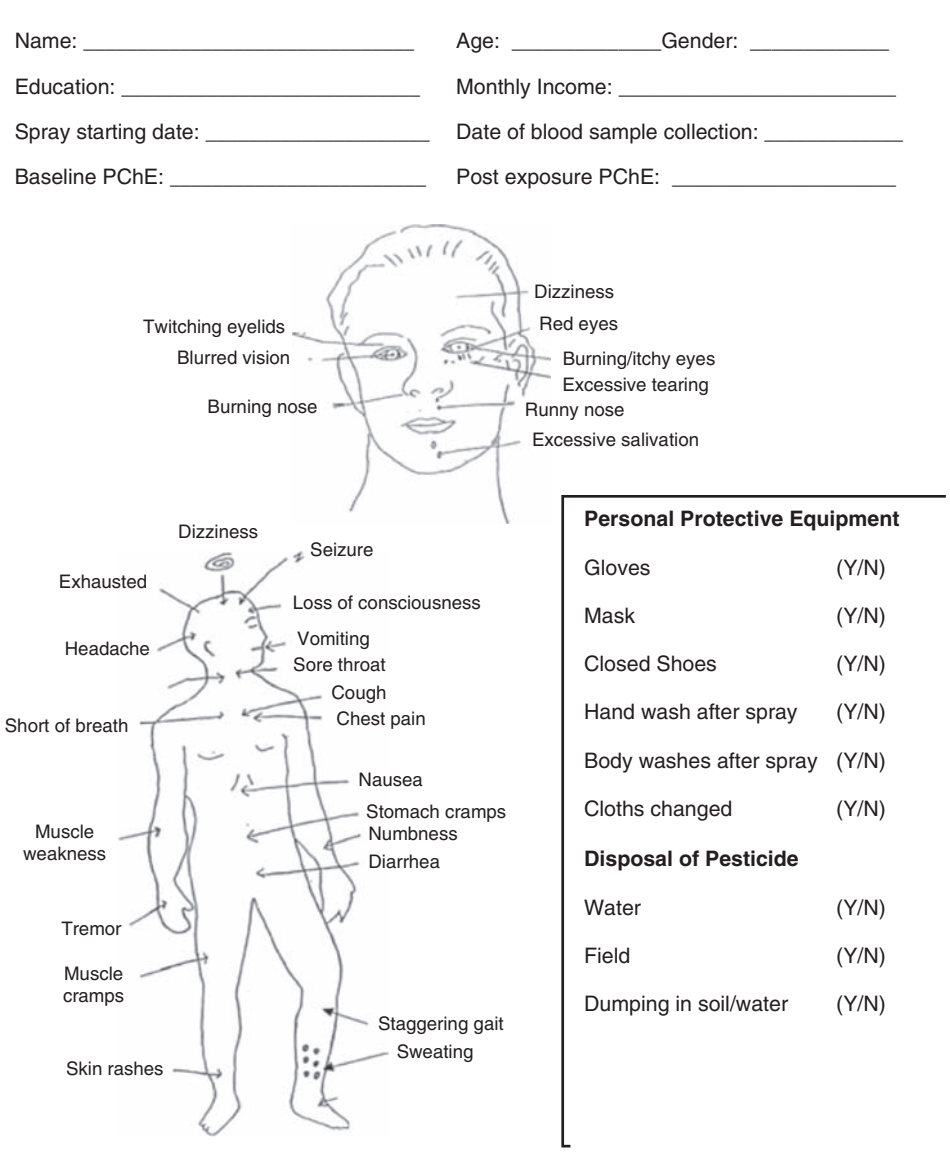

Figure 1. A standard questionnaire used for recording of clinical personal protective equipment information.

PChE levels were estimated by Ellman's method with Butyrylthiocoline (Ellman et al., 1961). The assay was performed by using Globe Diagnostic Italy kits by standard procedure on Vita Lab Selectra E (the Netherland) at the medical laboratory of Army Medical College, Rawalpindi. The CV of the method was found to be 3%. The interpretation of PChE test results was done by a licensed physician. On the basis of post-exposure depression in PChE levels from baseline, farmers were divided into three categories: normal poisoning, a decrease in PChE levels $<20\%$; mild poisoning, between 20–40% and moderate poisoning, $>40\%$ reduction from baseline levels (Furman, 2006).

Statistical Analysis

Statistical analysis was carried out using SPSS version-15. Descriptive analysis of PChE and protective measure variables were expressed as mean, standard error, confidence interval, frequency and percent. Odds ratio and confidence interval between pesticide applicators having PChE $<20\%$ and $>20\%$ depression were calculated. Fisher's exact test was applied according to the expected frequency for PPE data. Differences in the means of PChE among the three categories were analyzed by one-way ANOVA and *post hoc* Scheffe tests. A *P*-value of <0.05 was considered significant.

Results

Data were collected from 105 pesticide applicators consisting of 42 from Chota Lahore and 63 from Jangen Nath, both villages of district Swabi. The socio-demographic characteristic,

including age, educational levels and past experience of the farmers regarding pesticide handling is shown in Table 1. Tobacco farmers involved in pesticide handling were all males, with a mean age of 26 years, and ranged from 16 to 53 years. The females of this area did not participate in tobacco farming and pesticide-related activities. Among the male tobacco farmers, 42 (40%) were not literate and 36 (34%) had completed 10 years of education. All the subjects were full-time farmers and about half of them had 11–20 years' experience of pesticide application on the crop. Only 12 farmers had formal training in safe pesticide handling and spraying.

Table 1. Social and demographic characteristics of the tobacco pesticide applicators.

Characteristics	Tobacco pesticide applicator ($n=105$) n (%)
Age (years)	
16–20	12 (11.4%)
21–30	61 (58%)
31–40	19 (18.1)
41–50	11 (10.5)
>50	2 (1.9)
Education level	
Illiterate	42 (40.0)
1–5 (years of schooling)	19 (18.1)
6–10 (years of schooling)	36 (34.3)
11–16 (years of schooling)	8 (7.6)
Years of pesticide use experience	
1–10	31 (29.5)
11–20	47 (46.7)
21–30	22 (20.9)
>30	5 (4.8)

Health Hazards

Most of the farmers experienced multiple symptoms of the central nervous system, gastrointestinal and respiratory system during or after the spraying of the pesticide on the tobacco crop. The signs and symptoms were noted within 1–4 h after the spray by a licensed physician. Many of the symptoms appeared within an hour after pesticide spray and were consistent with the known toxicology of pesticides. The comparison of various clinical symptoms experienced by the farmers having mild and moderate pesticide poisoning is illustrated in Figure 2. Headache followed by nausea, dizziness, vomiting, shortness of breath, skin rash, redness of eyes and muscle weakness were significantly high among farmers with moderate pesticide poisoning as compared with the farmers with mild poisoning ($P \leq 0.001$). However, none reported any seizure and loss of consciousness.

The farmers involved in pesticide application on tobacco crop were classified into normal (<20% reduction), mild (20–40% reduction) and moderate (>40% reduction) categories on basis of post exposure depression of PChE levels from baseline (Figure 3). PChE concentration was significantly decreased (mean, 95% CI) in farmers having mild (mean 4625, 95% CI 4405–4846) and moderate (Mean 4261, 95% CI 3801–5039) toxicity as compared with healthy farmers (mean 5210, 95% CI 5074–5346) in post-spray period ($P \leq 0.001$). Out of 105 farmers, 58 (55%) were categorized into normal, whereas 35 (33%) had mild and 12 (11%) had moderate pesticide poisoning. The depression in PChE levels was correlated with clinical findings in tobacco farmers.

Knowledge

Most of the farmers 96 (91%) had knowledge about the detrimental health effects of pesticides, but were not aware of the recommended safety precautions regarding pesticide

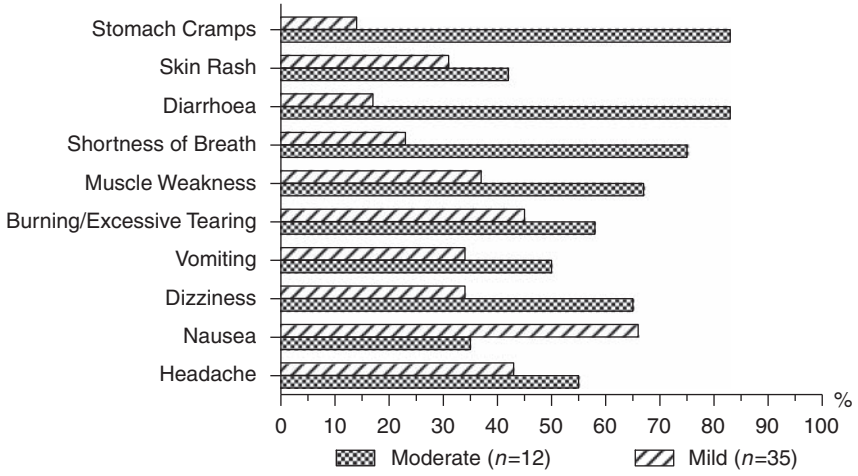

Figure 2. Comparison of clinical symptoms and sings reported by the farmers suffering from mild and moderate pesticide poisoning after pesticide spray on the tobacco crop.

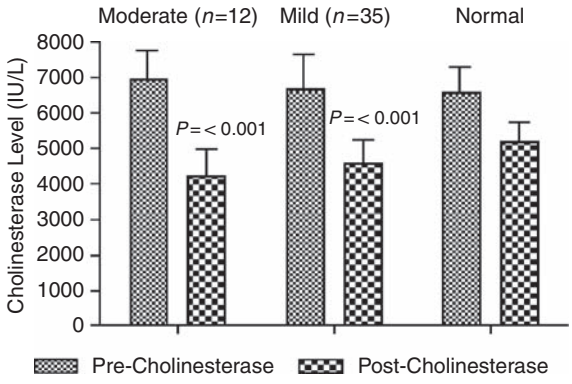

Figure 3. Post-spray plasma cholinesterase levels in the tobacco farmers ($n = 105$) having normal (<20%), mild (20–40%) and moderate (>40% depression) pesticides poisoning.

Figure 4. Mixing of pesticides and refilling knapsack spray's tank by tobacco farmers without wearing protective gloves and mask.

handling and application. The farmers knew the names of the applied pesticides, but they had no information about their toxicity class and hazardous health effects. The labels on pesticide containers were often written in English and Urdu languages with instructions on the use of PPE. A majority of the farmers were unable to comprehend the safety instructions written on them because their native language was Pashto. The farmers reported that pesticide information was most often received through oral communication with co-workers, radio and TV.

Observed practices

Six types of pesticides were used in the tobacco growing areas of Swabi. The farmers commonly used CM, Methomyl; WHO toxicity class Ib, highly hazardous marketed under the trade name of Lannate (63%) and Thiodicarb, Class II, moderately hazardous (56%). Methamidophos, marketed under the trade name Grip belonging to OP; Class Ib, highly hazardous was used by 62% of the farmers. Cypermethrin, toxicity Class II, moderately hazardous, was used by 36% of farmers. The organochlorinated compounds Thiodan (endosulphan) and Confidor (imidacloprid; toxicity Class II, moderately hazardous) were used occasionally.

The participants had a casual attitude towards storage, handling and disposal of the pesticides. A large majority of the farmers 67 (64%) did not store pesticide containers in proper storage places and were thus accessible to children and females at home. Only 38 (36%) stored pesticides in proper storage rooms.

Most of the farmers did not use basic protective equipments during pesticide handling and applications on the tobacco crop. Gloves and face masks were not commonly used while mixing pesticide and during the refilling of tanks (Figure 4). The comparison of PPE used by the farmers having normal PChE and pesticide poisoning is shown in Table 2. The farmers who had pesticide poisoning (PChE >20 depression) used significantly less numbers of PPE and safety measures as compared with the normal group (PChE<20 depression). None wore any protective head cover. However, many farmers reported washing their hands and bodies after spraying. Twenty-one (20%) farmers had knapsack sprayer tanks with ill-fitting nozzle. Most farmers wore traditional cotton shalwar kameez while working in the fields and covered their faces with a cotton cloth while spraying (Figure 5), which cannot be considered as a separate protective equipment gear. The pesticide applicators' back (9%) was in direct contact with pesticide mixtures owing to leakage of the tanks (Figure 5).

Disposal of empty pesticide containers was also not satisfactory. A majority of the farmers threw these containers either in the fields, 65 (62%), or in irrigating canals. We have collected 84 empty pesticide containers from the tobacco farms of the two villages (Figure 6). Almost 40 (38%) farmers discarded the empty containers either by burning or burying them in the soil.

Discussion

A comprehensive approach was used to evaluate the KAP among tobacco farm workers in district Swabi, NWFP, Pakistan. The effects of pesticide use on the tobacco farmers' health were for the first time assessed clinically, as well as by monitoring the PChE levels in the farmers. Most of the participants included in the survey were natives, that is, Pasthons, young males <30 years of age. The older people were not involved in pesticide application because of the hot climate and traditionally because young adults did not like their parents to work in the fields. Females did not participate in spraying or mixing of pesticides because of the cultural restraints. Females are typical housewives and work only inside their houses. Most of the farmers involved in pesticide handling were not literate and about half of the farmers had primary (up to 5 years of schooling) or secondary level (up to 10 years of schooling) education. The farmers with little formal education might be at a higher risk when using pesticides, possibly because of being unable to comprehend

Table 2. Comparison of personal protection equipments used by the farmers having <20% and >20% PChE depression after spraying on the tobacco corps ($n = 105$).

Personal protection equipments	Pesticide applicator with PChE depression <20% *n* (%)	Pesticide applicator with PChE depression >20% *n* (%)	X^2	OR	95% CI
Wore gloves					
Yes	8 (13.8)	1 (2.1)	4.5	7.4	0.9–61.1
No	50 (86.2)	46 (97.9)	$P \leq 0.034$		
Wore mask					
Yes	13 (22.4)	2 (4.3)	7.0	6.5	1.4–30.5
No	45 (77.63)	45 (95.7)	$P \leq 0.008$		
Wore boots					
Yes	24 (41.4)	7 (14.9)	8.8	4.0	1.4–10.5
No	34 (58.6)	40 (85.1)	$P \leq 0.003$		
Wore impermeable clothes					
Yes	17 (81.0)	4 (19.0)	7.0	4.5	1.4–14.4
No	41 (48.8)	43 (51.2)	$P \leq 0.008$		
Wore mask					
Yes	22 (71.0)	9 (29.0)	4.4	2.6	1.1–6.3
No	36 (48.6)	38 (51.4)	$P \leq 0.036$		
Hand wash after spraying					
Yes	56 (96.6)	37 (78.7)	8.2	7.6	1.6–36.5
No	2 (3.4)	10 (21.3)	$P \leq 0.004$		
Showered after spraying					
Yes	55 (94.8)	37 (78.7)	6.2	4.9	1.3–19.2
No	3 (5.2)	10 (21.3)	$P \leq 0.013$		
Changed clothes after spraying					
Yes	57 (98.3)	41 (87.2)	5.1	8.3	0.9–71.9
No	1 (1.7)	6 (12.8)	$P \leq 0.024$		

Figure 5. The farmer is spraying pesticides on tobacco crop without taking any protective measures.

Figure 6. Empty pesticide containers collected from field during survey.

the instructions written in English on the pesticide containers. They spoke and understood only their native language (Pashto). Most of the pesticide formulation industry did

provide the labels with proper safety measures instructions. A vast majority of the farmers (88%) in the study had never received any formal training on the use of pesticides and knap sprayers, learning methods of spraying pesticide handling and tank filling by imitating their relatives or neighbors.

The farmers mostly complained of headache, dizziness, nausea, vomiting, respiratory problems and eye symptoms, which are most likely because of acute pesticide poisoning (Murphy et al., 2002). The signs and symptoms were consistently a lack of safety equipment used with the toxicity of commonly used pesticides (CM and OP). During the survey, the sign and symptoms were explained to the farmers before the recruitment of participants at start of the tobacco growing season as a part of the general awareness program. This enabled the farmers to explain to the doctors the signs and symptoms experienced during evaluation of practices. Most existing studies are based on self-reported symptoms by farmers (Murphy et al., 2002; Recena et al., 2006). However, these symptoms are general in nature and mimic other common health problems. Therefore, appropriate biochemical tests are required to clinically correlate the signs and symptoms with acute pesticide poisoning for confirmation of diagnosis. We believe that our results are of particular interest because they rely not only on the conventional self-reporting symptoms, but also on the PChE levels to determine pesticide poisoning.

In our study, markedly decreased PChE from baseline levels after the spraying session within 1–2 h suggest that the frequency of poisoning from exposure to OP and CM is quite high in our tobacco farmers. Most of the OP and CM insecticides inhibit the PChE, which is helpful for detecting the early acute effects of poisoning and monitoring the pesticide exposure. Similar results were noted among the tobacco farmers of many other countries (Cornwall et al., 1995; McDaniel et al., 2005; Damalas et al., 2006; Peres et al., 2006; Dasgupta et al., 2007). With an increase in the levels of pesticide residues in blood, there is inhibition of PChE showing lowest levels in the farmers of moderate severity. In our study, decreased levels of PChE were seen to be consistent with mild to moderate pesticide toxicity. We measure the PChE immediately after the exposure to detect pesticide poisoning, not the green tobacco sickness. Pesticide poisoning among farmers and workers in developing countries is alarming (McCauley et al., 2006).

According to the Washington State Guidelines for agricultural pesticide handlers (Furman, 2006), farmers should not work with pesticides until their cholinesterase activity levels recover back to $<20\%$ from the baseline values. As PChE is regenerated quickly in the liver, follow-up testing to monitor recovery after a depression $>40\%$ from baseline should be carried out repeatedly until the level returns to within 20% of baseline. On the basis of these guidelines, 12 of our farmers who had moderate pesticide toxicity should have been removed from the pesticide-exposed areas and 35 mild cases needed to be evaluated for their safety practices. The local health authorities were informed about the farmers to take required necessary action.

It was observed that considerable number of farmers in our study did not use PPE on regular basis. Farmers normally worked barefooted and wore improper clothing, which exposed them to the harmful effects of pesticides. Most farmers wore traditional cotton shalwar kameez, which cannot be considered as a separate protective equipment gear. Only a small number of farmers used gloves while handling pesticides and most farmers did not wear protective gloves while mixing and refilling pesticide tanks. They had direct contact with the pesticides and their hands became wet with the chemicals while mixing pesticides. A few wore proper face masks, and the rest did not cover their faces during spraying or even if they did, they used a small cotton cloth. Similar practices were observed in the Indian farmers. Mancini et al. (2005) observed that the use of protective measures and equipment for the safe handling and spraying of pesticides is far from being adopted (Mancini et al., 2005).

This is due to the lack of education and training in safe pesticide handling and an insight into the importance of PPE use. In addition, farmers' cash income is often inadequate for purchasing such protection gear. Farmers were also insufficiently aware of the effects of pesticides to convince them to wear protective clothing while handling pesticides. Other factors that may contribute to not wearing PPE is that the tropical environment makes the wearing of PPE difficult because of the potential for heat stress. Another contributing factor in acute pesticide poisoning in our farmers was poorly maintained knapsack sprayers. Most farmers had wet clothes owing to leakage from ill-fitting nozzles and poorly kept equipment during the spraying. It was observed that most of the equipment that was in use was locally made and was of poor quality. Many of the knapsack sprayers had been there for years without any maintenance, repair or replacement by new equipment. The lack of training and unavailability of safety equipment is consistent with other studies (Zhang and Lu, 2007; Snelder et al., 2008).

Lack of protective equipment use has been reported among farmers of many countries, for example, Australia (MacFarlane et al., 2008), Brazil (Recena et al., 2006), Sri Lanka (Sivayoganathan et al., 1995), Egypt (Stewart, 1996), Gaza strip (Yassin et al., 2002), Ethiopia (Mekonnen and Agonafir, 2002) and United Arab Emirates (Gomes et al., 1999).

Diverse trends were seen regarding the disposal of pesticide residues. Owing to the casual attitude towards the handling of pesticides, many farmers threw pesticide containers in fields or irrigating water causing environmental pollution and health hazards in the community. This malpractice causes

increased pesticide residues in human blood and water (Ansari et al., 1997; Ahad et al., 2006).

Proper training in pesticide handling, education on hazards of pesticide exposure and safe disposal would substantially decrease the health risks faced by the farmers. Farmers' awareness of the health-related pesticide risks and the necessity of using protective clothing can be further raised by including visual instructions on pesticide formulation packing labels, in addition to adequate warning labels written in native language. Emphasis should be laid on the importance of protective equipment by farmers during work to diminish the hazards of pesticide toxicity. Educational and technical support programs should be introduced to increase safe practices among pesticide users. The practical implication of knowledge to decrease the health effects of pesticides might prove to be a complex task. This requires the active participation of the local regional agricultural department and government. Government policies regarding the safe pesticide handling, availability and use of toxic chemicals should be revised to restrict the use of highly hazardous pesticides such as CM and OP, which was frequently used by our farmers. Local authorities should take immediate actions to implement these policies.

This study can be considered as representative of current practices adopted by the tobacco farmers in district Swabi where 73% of the total tobacco of the country is grown. As the current practices of the farmers are identical throughout the region, it can be considered as representative of the whole province of NWFP, Pakistan. Our results highlight the potential importance of training on pesticide handling and use of PPE. Inculcating such actions would substantially decrease the pesticide-related toxicity among farmers and would also decrease the pesticide-related local water and soil contamination.

Conclusion

It is concluded that our tobacco farmers experienced a variety of clinical symptoms as a result of pesticide toxicity, which was correlated with depression in PChE levels. Furthermore, most farmers had little knowledge about the safety measures, a casual attitude and unsatisfactory safety practices with regard to the use of basic protective equipments during pesticide applications on the tobacco crop. Awareness about pesticide toxicity, training, a change in attitude and practices to adopt PPE are essentially required for prevention of hazardous health effects.

Acknowledgements

This study was a part of the Project No. 20-736/R & D/06/2119 entitled ''The Effects of Environment Pesticide Residues on the Health of Farmers in Tobacco growing areas of NWFP, Pakistan'' supported by the Higher Education Commission (HEC), Pakistan, under national research program for universities.

References

Ahad K., Mohammad A., Mehboob F., Sattar A., and Ahmad I. Pesticide residues in Rawal Lake, Islamabad, Pakistan. *Bull Environ Contam Toxicol* 2006: 76(3): 463–470.

Azmi M.A., Naqvi S.N.H., Azmi M.A., and Aslam M. Effect of pesticide residues on health and different enzyme levels in the blood of farm workers from Gadap (rural area) Karachi-Pakistan. *Chemosphere* 2006: 64(10): 1739–1744.

Ansari M.T., Iqbal Z., and Ahmad B. Organochlorine pesticide residues in human blood in the population of Multan (Pakistan). *Pak J Pharm Sci* 1997: 10(1): 19–28.

Cornwall J.E., Ford M.L., Liyanage T.S., Win Kyi Daw D., Cornwall J.E., and Ford M.L., et al. Risk assessment and health effects of pesticides used in tobacco farming in Malaysia. *Health Policy Plan* 1995: 10(4): 431–437.

Damalas C.A., Georgiou E.B., and Theodorou M.G. Pesticide use and safety practices among Greek tobacco farmers: a survey. *Int J Environ Health Res* 2006: 16(5): 339–348.

Dasgupta S., Meisner C., Wheeler D., Xuyen K., and Thi Lam N. Pesticide poisoning of farm workers—implications of blood test results from Vietnam. *Int J Hyg Environ Health* 2007: 210(2): 121–132.

Ellman G.L., Courtney K.D., Andres Jr V., and Feather-Stone R.M. A new and rapid colorimetric determination of acetylcholinesterase activity. *Biochem Pharmacol* 1961: 7: 88–95.

Furman J. Cholinesterase monitoring for agricultural pesticide handlers. Guidelines for health care providers in Washington state Website. 2006: http://www.lni.wa.gov/Safety/Topics/A to Z/Cholinesterase/files/Providers Guidelines 1.

Gomes J., Dawodu A.H., Lloyd O., Revitt D.M., and Anilal S.V. Hepatic injury and disturbed amino acid metabolism in mice following prolonged exposure to organophosphorus pesticides. *Hum Exp Toxicol* 1999: 18(1): 46–65.

Khan M.F., Khan M.I., Aslam M., and Naqvi S.N.H. Study of cholinesterase level in blood of cotton field workers exposed to pesticides. *J Baq Med Univ* 2000: 3: 12–16.

MacFarlane E., Chapman A., Benke G., Meaklim J., Sim M., and McNeil J. Training and other predictors of personal protective equipment use in Australian grain farmers using pesticides. *Occup Environ Med* 2008: 65: 141–146.

Mancini F., Van Bruggen A.H.C., Jiggins J.L.S., Ambatipudi A.C., and Murphy H. Acute pesticide poisoning among female and mâle cotton growers in India. *Int J Occup Environ Health* 2005: 11(3): 221–232.

McCauley L.A., Anger W.K., Keifer M., Langley R., Robson M.G., and Rohlman D. Studying health outcomes in farmworker populations exposed to pesticides. *Environ Health Perspect* 2006: 114(6): 953–960.

McDaniel P.A., Solomon G., and Malone R.E. The tobacco industry and pesticide regulations: case studies from tobacco industry archives. *Environ Health Perspect* 2005: 113(12): 1659–1665.

Mekonnen Y., and Agonafir T. Pesticide sprayers' knowledge, attitude and practice of pesticide use on agricultural farms of Ethiopia. *Occup Med (Lond)* 2002: 52(6): 311–315.

Murphy H.H., Hoan N.P., Matteson P., and Morales Abubakar A.L.C. Farmer's self-surveillance of pesticide poisoning: a 12-month pilot in Northern Vietnam. *Int J Occup Environ Health* 2002: 8(3): 201–221.

Pakistan Tobacco Board. Ministry of commerce Govt. of Pakistan Peshawar Tobacco statistical bulletin, 2004.

Peres F., Moreira J.C., Rodrigues K.M., and Claudio L. Risk perception and communication regarding pesticide use in rural work: a case study in Rio de Janeiro State, Brazil. *Int J Occup Environ Health* 2006: 12(4): 400–407.

Recena M., Caldas E., Pires D., and Pontes E. Pesticides exposure in Culturama, Brazil: knowledge, attitudes, and practices. *Environ Res* 2006: 102(2): 230–236.

Reeves M., and Schafer K.S. Greater risks, fewer rights: U.S. farmworkers and pesticides. *Int J Occup Environ Health* 2003: 9(1): 30–39.

Sivayoganathan C., Gnanachandran S., Lewis J., and Fernando M. Protective measure use and symptoms among agropesticide applicators in Sri Lanka. *Soc Sci Med* 1995: 40(4): 431–436.

Snelder D.J., Masipiqueña M.D., and de Snoo G.R. Risk assessment of pesticide usage by smallholder farmers in the Cagayan Valley (Philippines). *Crop Prot* 2008: 27: 747–762.

Stewart D.J. Pesticide use, habits and health awareness among Egyptian farmers. *Ambio* 1996: 25(6): 425–426.

World Health Organization Bulletin. 2008: 86(3): 205.

World Health Organization. WHO recommended classification of pesticides by hazards and guidelines to classification. Geneva; WHO/PCS/01.4 2001.

Yassin M.M., Abu Mourad T.A., and Safi J.M. Knowledge, attitude, practice, and toxicity symptoms associated with pesticide use among farm workers in the Gaza Strip. *Occup Environ Med* 2002: 59: 387–393.

Zhang H., and Lu Y. End-users' knowledge, attitude, and behavior towards safe use of pesticides: a case study in the Guanting Reservoir area, China. *Environ Geochem Health* 2007: 29: 513–520.