ORIGINAL ARTICLE *Al Ameen J Med Sci (2010)3(1):58-64*
ISSN 0974-1143

Respiratory Dysfunctions Related to Insecticide Exposure Among Farmers in Sindh, Pakistan

Ali Muhammad Soomro[1], Nasim Aslam Channa[2] and Arif Siddiqui[3]
[1]Faculty of Pharmacy, [2] Institute of Biochemistry University of Sindh, Jamshoro-76080,Sindh,Pakistan and [3] National Institute of Health Sciences, Islamabad, Pakistan

Abstract The insecticide effect on lung physiology is well reported. Data on respiratory dysfunction after insecticide exposure to farmers are scanty in Pakistan. Present study was designed to determine the frequency and reported respiratory symptoms among two groups of farmers. One group comprised of 'insecticide spray-workers' (n=324) and other group was of non users of agrochemical substances, i.e. the comparison group (n=209). Male farmers between the ages of 25 to 45 years, and who were non smokers were enrolled in the study from various areas of Sindh province (Pakistan) during agriculture crop season 2006-07. The farmers were introduced a questionnaire gleaning information on farming characteristics and respiratory symptoms. Spirometry was carried out to assess lung functions. Computer software Minitab 8.0 version was used to analyze data. A greater proportion of insecticide spray workers reported respiratory symptoms; dyspnea, bronchitis, asthma and rhinitis as compared to farmers who did not handle insecticides. Comparative values of FEV1 and FEV_1/FVC ratio were also significantly low in insecticide spray workers. The results suggest that obstructive and restrictive lung functions are more prevalent in the farmers who were exposed to insecticides than non user comparison group. These differences were statistically significant.
Keywords: Insecticides, Spirometry, Farmers

Introduction

Insecticides use in agriculture sector has been considered a risk for development of respiratory problems [1-2]. Respiratory symptoms such as wheezing, difficulty in breathing and cough are, not specific to exposure to pesticides, but can also occur to conditions such as exposure to pollens and to other occupational exposures [3-4]. A prolonged insecticide exposure in agriculture settings might result in chronic airflow limitation through airway obstruction or loss of elastic recoil in damaged parenchyma. In this framework the development of restrictive and /or obstructive respiratory findings in crop farmers may be associated with exposure to a variety of insecticides as well [5-6]. Information on respiratory illness related to insecticide exposure is scant from Pakistan. Only one survey from province of Sindh, Pakistan reported a significant increase in respiratory disorders among the farmers who were exposed to pesticides [7]. Studies from developed countries suggest that the morbidity and mortality rates due to certain respiratory disorders are higher in farmers as compared to the general population and are most likely due to occupational contact to insecticides [8-10]. Airway obstruction in agriculture farmers is reported with use of insecticide products belonging to classified chemical groups like organochlorines, organophosphates, carbamates and pyrethroids [11-12]. Due to their toxic effects it has been a recommendation, to further evaluate the lung function measurements in the farmers who are exposed to these chemicals. Acute reduction in forced expiratory volume in one second (FEV_1) is also reported by some researchers

[13-15]. Gamsky *et al* 1992, have shown that California grape workers had lower forced vital capacity (FVC) compared to tomato and citrus workers [16]. To the best of knowledge no such reports are cited in literature on lung function tests in farmers at provincial and/or national level in Pakistan. Therefore, the objectives of this study were to find out the frequency and level of respiratory morbidity on lung function among the farmers' population from Province of Sindh Pakistan.

Materials and Methods

Study Population: A comparison of two population proportions were carried out to compare the frequency of respiratory symptoms and lung function tests among farmers who were exposed to insecticides (n= 324) and who never handled any insecticides (n= 209). Our sample size was based on hypothesis testing for two population proportions (two sided test). Study participants were exclusively non-smokers agriculture male farmers, living in different areas of Sindh province of Pakistan. A study questionnaire was specifically designed for the study purpose to glean information on demographics and lifestyle, work history, occupational exposures, and the presence of respiratory symptoms in farmers. The study was conducted during agriculture crops for the year 2006-07. Convenient sampling method was used to identify the study subjects. Farmers who fulfilled the laid down eligibility criteria i.e. exposed or non-exposed status to insecticides and being non smokers. Both groups were matched on age.

Spirometry: Lung function examination was carried out in triplicate by a trained technician, using a daily-calibrated hand-held spirometer (SP2). Each participant completed a dynamic spirometry and the values were expressed in liters for FEV_1 and FVC while FEV_1/FVC ratio calculated in percentage. .

Data analysis: Data were analyzed using Minitab software version 8.0. Initially data collected by questionnaire were calculated in percentile and T-test was applied for data on spirometry.

Results

We were able to interview 340 farmers in the exposed group and 220 farmers in the comparison group. Farmers interviewed were between the ages of 25-45 years. Three of the subjects from the comparison group and six from the exposed group were removed from the final analysis due to inconsistencies in the data. However, eight subjects in the comparison group and ten in the exposure group were kept in the analysis as information was missing on few variables. Selection of participating comparison group (controls) and spray workers at crops (subjects) is given in Table 1

Table 1

Selection of participating controls, and subject farmers at crop

Farmers in approach	Control (220)	Subject (340)	Farmers at Crop		
			Cotton orchards (140)	Vegetable (110)	Mango (90)
	(n) (%)	(n) (%)	(n) %	(n) (%)	(n) (%)
Real Participants	209 (95%)	324 (95.29%)	133 (95%)	105 (95.45%)	86 (95.55%)
Partial Participants	08 (3.63%)	10 (2.94%)	4 (2.85%)	04 (3.63%)	02 (2.22%)
Ineligible	03 (1.36%)	6 (1.76%)	3 (2.14%)	01 (0.9%)	02 (2.22%)

Farmers in the exposed group reported handling, mixing, loading and spraying insecticides by "Back pack sprays" without putting on 'European style safety kit' for their protection. Insecticide products used as routine for crop protection were from four chemical groups namely organochlorines, organophosphates, carbamates and pyrethroids. Sprays were done during morning hours for three to six times in each spray-season for cotton, tomato and mango-orchards.

Table 2
Insecticides sprayed per crop season by subject farmers

Insecticide	**Chemical group**	**WHO Classification by Hazard**	**Sprays per crop season**
Parathion	Organophosphates	1 A	05
Monocrotophos 36% SL	Organophosphates	1 B	04
Phorate 10% G	Organophosphates	1B	03
Triazophos 40% EC	Organophosphates	1B	04
Chlorpyriphos 20% EC	Organophosphates	2	05
Profenophos 50% EC	Organophosphates	2	04
Dimethoate 30% EC	Organophosphates	2	05
Endosulfan 35 EC	Organochlorines	2	06
Carbofuran	Carbamates	2	03
Carbaryl	Carbamates	2	03
Lambda cyhalothrin 5%	Pyrethroids	2	05
Cypermethrin 25% EC	Pyrethroids	2	05
Fenvalerate 20% EC	Pyrethroids	3	04

Table 2 describes the insecticides and their chemical group categorized according to WHO classification by hazard it causes, and number of sprays during each crop season.

Table 3
Number and percentage of the farmers having respiratory symptoms

Farmers	SYMPTOMS				Farmers without symptoms
	Asthma	Bronchitis	Dyspnoea	Rhinitis	
Control (n=209)	3 (1.43%)	9 (4.30%)	11 (5.26%)	14 (7.70%)	172 (82.30%)
Subject (n=324)	8 (2.47%)	86 (26.54%)	128 (39.50%)	69 (21.30%)	33 (10.18%)

Table 3 give a comparison of respiratory symptoms experienced by farmers exposed to insecticides and those who never handled insecticides in life time. Generally a large proportion of farmers in the exposed group reported one or the other of the respiratory symptoms. Dyspnoea and bronchitis were the most common symptoms reported by the farmers who were exposed to the insecticides handling. The majority of farmers who never handled insecticides were symptoms free unless they had other reasons to suffer.

Table 4

Percentage of subject farmers exposed to insecticide groups showing occurrence of respiratory symptoms

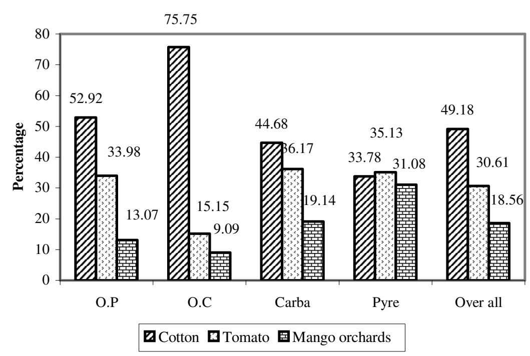
Subject Farmers	SYMPTOMS Asthma	Bronchitis	Dyspnoea	Rhinitis	Symptomatic	Asymptomatic
Carbamates (n=54)	1 (1.85%)	16 (29.63%)	21 (38.88%)	8 (14.81%)	46 (85.18)	8 (14.81%)
Organophosphates (n=160)	4 (2.50%)	44 (27.50%)	64 (40.0%)	35 (21.87%)	147 (91.87%)	13 (8.12%)
Organochlorines (n=32)	2 (6.25%)	9 (28.12%)	13 (40.62%)	6 (18.73%)	30 (93.75%)	2 (6.25%)
Pyrethroids (n=78)	1 (1.29%)	17 (21.80%)	30 (38.47%)	20 (25.65%)	68 (87.17%)	10 (12.82%)

Table 4 describes the percentile of only subject farmers exposed to insecticide groups, most of them were affected (symptomatic) and very few were safe (asymptomatic). Consequently organophosphates and organochlorines both were recorded for inducing dyspnoea, carbamates for brochitis, pyrethroids for rhinitis and organochlorines for asthma in the symptomatic subject farmers.

It is interesting to note that respiratory symptoms were also related to the type of crop and insecticide used. It was noted that farmers exposed to organophosphates and carbamates, following sprays on cotton crop were the worst hit for respiratory disorders. Symptoms were significantly low in farmers to spray on tomato and mango crops as revealed in Figure 1.

Figure 1

Farmers with respiratory symptom percentage at crop after exposure to insecticide groups



The differences in the respiratory symptoms between the two groups were statistically significant after assessing lung air flow. The levels of FEV_1, FVC and FEV_1/FVC ratio, were assessed by spirometry on both exposed (subjects) and comparison groups (controls). Here the low levels of FEV_1, FVC and FEV_1/FVC ratio, in the subjects as compared to the control group, were seen. These differences observed were statistically significant (Table 5).

Table 5

T-test for lung function tests indicating level of significance amongst the farmers (worked out at 95% confidence limit)

Lung Functions	Exposed to insecticides (subjects)	Never handled insecticides (controls)	t-test
	Mean ± S.D	**Mean ± S.D**	**p-value(≤ 0.05)**
FEV_1 (Liters)	3.970 ± 0.058	4.670 ± 0.221	0.001
FVC (Liters)	5.036 ± 0.093	5.216 ± 0.071	0.001
FEV_1/FVC (%)	78.69 ± 4.06	89.41 ± 5.03	0.001

Discussion

The higher proportion of respiratory symptoms and low levels of lung function tests in farmers exposed to insecticide spray are strongly suggestive of the dire health consequences in farmers who are engaged in such activities. The insecticides used by the farmers for crop protection in Sindh are already under WHO classification, as hazardous if not used with appropriate precautions. By virtue of their hazardous class and mode of action as 'neurotoxic', these may be associated with disruption in respiratory functions [17]. This linkage was further supported as farmers reported insecticide spray without taking appropriate self-protective measures that allow free entry of insecticides in different organ systems of the body. The protective gears and safety equipments have not been designed to be used by the workers for humid tropics like Pakistan resulting in their non- efficiency or non-use [18]. We selected those farmers as our study subjects who were non smokers to control for symptoms resulting due to prolonged smoking. Respiratory symptoms recorded in study population unveiled higher percentile of dyspnoea (39.50%), bronchitis (26.54%), rhinitis (21.30%) and asthma (2.47%) in the farmers working as spray-men. Whereas complains of dyspnoea (5.26%), bronchitis (4.30%), rhinitis (7.70%) and asthma (1.43%), were lesser in the comparison group. Our results are consistent with previous studies conducted using international standardized questionnaires, where prevalence of respiratory symptom rate varies between 7–26% among various farming populations [19-20]. Most of the products reported by our study participants are known neurotoxins, and cholinesterase inhibitors. Acetylcholine is a powerful respiratory stimulant [21], its synthesis, identification and destruction is differentiated in the medullary region of brain that contains respiratory neurons [22-23]. Organophosphates put forth their effects by inhibition of acetylcholinesterase and consequent increase in acetylcholine. Some authors reported respiratory failure, a well-known characteristic of acute organophosphate poisoning with an early central apnea followed by later pulmonary effects [24-26]. Therefore the symptoms reported in this study and insecticide exposure consistently verify the probable role of cholinesterase inhibitors for respiratory dysfunctions in the farmer community. Table 4 and Figure 1 show the effects on the group exposed to insecticides, placing organochlorine as most injurious, followed by cholinesterase inhibitors (organophosphates and carbamates) then pyrethroids responsible for respiratory dysfunctions in the subject farmers. The uptake of such toxic insecticides in the lungs and prolonged retention of its inhaled particles causes inflammation of lung parenchyma and damage to the tissues [27-29]. Depending on the chemical nature and usage, the insecticides were witnessed for their toxic effects, as present results reveal the difference in percentage of symptomatic and asymptomatic subject farmers who sprayed cholinesterase inhibitors; the organophosphates and carbamates (Table 4). Figure 1 shows highest percentage (75.75%) of subject farmers with respiratory symptoms after exposure to organochlorines followed by cholinesterase inhibitors at cotton crop. Increased number of sprays given to the cotton crop may be the reason for its intense effect. Many agro-chemical products were reported for highly toxic effects on pneumocytes, inducing inflammation and known responsible for lung injury a major reason towards respiratory dysfunctions. Prevalence and extent of insecticide associated lung function examined by spirometry was not reported in the farmers of Sindh, though some reference values for lung function were reported in the Pakistani population [30]. Using this technique, Dosman *et al* (1987) reported significantly lower FVC, FEV_1, FEV_1/FVC values in farmers compared to control subjects, with pronounced differences in farmers belong to middle-ages [31]. Iversen and Pedersen (1990) on the other hand have found no significant impairment of lung function in farming populations compared with controls, despite increasing symptoms [32]. Interpretations of present findings indicate significant differences ($p<0.001$) in mean values for FEV_1, FVC and FEV_1/FVC ratio (Table 5), which reveal both obstructive, and restrictive lung functions in the farmers exposed to insecticides. However, increasing rate of respiratory dysfunction among the farmers exposed to insecticides in this work was seen apparent in the exposed group as compared to comparison group at similar inhabitancy.

Conclusions

Present results thus provide evidence that prevalent insecticide spray practices affects on respiratory functions in the farmers in a significantly deleterious manners, especially those working in cotton crops. This work suggests undertaking additional studies on women and children of farmer communities to assess gender and age-dependent variations.

References

1. American Thoracic Society (ATS). Respiratory health hazards in agriculture. *Am J Respir Crit Care Med* 1998. 158(5 Pt 2):S1-S76.
2. Kimbell-Dunn MR., Fishwick, RD., Bradshaw L., Erkinjuntti-Pekkanen R., Pearce N. Work-related respiratory symptoms in New Zealand farmers. *Am J Ind Med* 2001.39: 292-300.
3. Zejda, JE., Dosman, JA. Respiratory disorders in agriculture. *Tuber Lung Dis.* 1993.74, 74–86
4. Linaker C., Smedley J. Respiratory illness in agricultural workers. *Occup Med. (Lond).* 2002.52: 451–59
5. Iversen M., Pedersen B. Relation between respiratory symptoms, type of farming and lung function disorders in farmers. *Thorax,* 1990. 45: 919–23.
6. Brauer MJ. Blair J, Vedal S. Effect of ambient ozone exposure on lung function in farm workers. *Am. J. Respir. Crit. Care Med.,* 1996.154: 981–87.
7. Soomro AM, Ansari AF., Seehar GM. Pesticide toxicity in the farmers of Sindh. (an epidemiological study). *Annals of KEMC Lahore.* 2003. 9(3):192-95
8. Heller RF, Kelson MC. Respiratory disease mortality in agricultural workers in eight member countries of the European Community. *Int J Epidemiol.* 1982.11:170–74.
9. Toren K, Horte LG, Jarvholm B. Occupation and smoking adjusted mortality due to asthma among Swedish men. *Br J Ind Med* 1991. 48: 323–26.
10. Office of Population Censuses and Surveys (OPCS), Health & Safety Executive. Occupational Health Decennial Supplement. 1995.London: HMSO.
11. Hoppin JA, Umbach DM, London SJ, Alavanja MC, Sandler DP. Chemical predictors of wheeze among farmer pesticide applicators in the agricultural health study. *Am J Respir Crit Care Med*. 2002. 165(5): 683-89.
12. Beard J., Sladden T., Morgan G., Berry G., Brooks L., McMichael A. Health impacts of pesticide exposure in a cohort of outdoor workers. *Environ Health. Perspect.,* 2003.111(5): 724-30.
13. Chan-Yeung M., Wong R., Maclean, L. Respiratory abnormalities among grain elevator workers. *Chest* 1979; 75: 461–67.
14. Donham, KJ., Cumro D., Reynolds SJ, Merchant JA. Dose–response relationships between occupational aerosol exposures and cross-shift declines of lung function in poultry workers: recommendations for exposure limits. *J. Occup. Environ. Med.,* 2000. 42: 260–69.

15. Radon K, Weber C, Iversen M, Danuser B, Pedersen S. Nowak D. Exposure assessment and lung function in pig and poultry farmers. *Occup. Environ. Med,*. 2001. 58: 405–10.
16. Gamsky TE, McCurdy SA, Samuels SJ, et al. Reduced FVC among California grape workers. *Am. Rev. Respir. Dis.* 1992; 145:257–62
17. Salome CM, Marks GB, Savides P, Xuan W, Woolcock AJ. The effects of insecticide aerosols on lung function, airway responsiveness and symptoms in asthmatic subjects. *Eur. Respir. J.* 2000.16: 38–43.
18. Wesseling C., McConnell R., Partanen T., Hogstedt C. Agricultural pesticide use in developing countries: health effects and research needs. *Int J Health Serv.* 1997.27: 273–308.
19. Choudat D., Goehen M., Korobaeff M., Boulet A., Dewitte JD., Martin MH. Respiratory symptoms and bronchial reactivity among pig and dairy farmers. *Scand J Work Environ Health.* 1994; 20: 48–54.
20. Sprince, NL., Lewis MQ., Whitten PS., Reynolds SJ., Zwerling, C. Respiratory symptoms: Associations with pesticides, silos, and animal confinement in the Iowa Farm Family Health and Hazard Surveillance Project. *Am J Ind Med*., 2000.38(4): 455-62.
21. Burton MD., Johnson DC., Kazemi, H., CSF acidosis augments ventilation through cholinergic mechanisms, J. *Appl. Physiol* 1989*.,* 66 : 2565-2572.
22. Cortes R., Probost A, Palacios JM. Quantitative light microscopic autoradiographic localization of cholinergic muscarinic receptors in the human brain: brainstem, *Neuroscience* 1984*,* 12 : 1003-1026.
23. Kasa, P. The cholinergic systems in brain and spinal cord, *Prog. Neurobiol* 1986*.,* 26 (1): 211-272.
24. Goswamy R, Chaudhuri A, Mahashur AA. Study of respiratory failure in organophosphate and carbamate poisoning. *Heart Lung* 1994;23(6):466–72.
25. Munidasa UA, Gawarammana IB, Kularatne SA, Kumarasiri PV, Goonasekera CD. Survival pattern in patients with acute organophosphate poisoning receiving intensive care. *J Toxicol Clin Toxicol* 2004;42(4):343–7.
26. Gaspari RJ, Paydarfar D. Pathophysiology of respiratory failure following acute dichlorvos poisoning in a rodent model. *Neurotoxicology* 2007;28(3):664–71.
27. Dungworth DL. Noncarcinogenic responses of the respiratory tract to inhaled toxicants. In: Concepts in Inhalation Toxicology (McClellan RO, Henderson RF, eds). New York: Hemisphere, 1989;273-98.
28. Smith LL. Mechanism of paraquat toxicity in lung and its relevance to treatment. *Hum Toxicol* 1987*;* 6: 31–36.
29. Bagchi D, Bagchi M, Hassoun EA, Stohs SJ. 1995. In vitro and in vivo generation of reactive oxygen species, DNA damage and lactate dehydrogenase leakage by selected pesticides. *Toxicology* 104: 129–40.
30. Siddiq M, Zaheer ud Din, Beg Z. Spirometric values in normal Pakistani population. *Pak Armed Forces Med J* 1997; 47: 41-44.
31. Dosman JA., Braham BL., Hall D., Van Loon P., Bhasin P., Froh, F. Respiratory symptoms and pulmonary function in farmers. *J. Occup. Med*. 1987; .29: 38–43.
32. Iversen, M., Korsgaard J,Hallas T, Dahl, R.,. Mite allergy and exposure to storage mites and house dust mites in farmers. *Clin. Exp. Allergy* 1990.20: 211-19.

*All correspondences to Dr. Ali Muhammad Soomro, Associate Professor, Department of Pharmacology, Faculty of Pharmacy, University of Sindh, Jamshoro, PAKISTAN, e-mail. soomroam@hotmail.com