RESPIRATORY HEALTH EFFECTS OF COTTON INHALABLE DUST ON WORKERS IN THE GARMENT PROCESSING UNIT

A. Mahmood, H. Ilyas*, M. N. Chaudhry* and A. Ali

Center for the Improvement of Working Conditions and Environment (CIWCE), Labour and Human Resource Department, Government of Punjab, Lahore.
*College of Earth and Environmental Sciences, University of Punjab, Lahore, Punjab, Pakistan.
Corresponding author's email: arshadhset@gmail.com

ABSTRACT: A cross-sectional study was conducted among 150 garment factory workers selected with stratified random sampling technique to examine their lung impairment with respect to cotton dust. Vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), forced vital capacity ratio (FEV_1/FVC) and forced expiratory flow ($FEF_{(25\%-75\%)}$) were obtained according to American Thoracic Society criteria. Exposure to cotton inhalable dust concentration was measured in accordance with National Institute of Occupational Safety and Health criteria. Mann Whitney U test was used for comparison among target groups and statistical significance of the study was set at $p<0.05$. Cough, phlegm and dyspnea was observed in 78%, 51% and 44% patients (workers) respectively. Personal exposure of the subjects to cotton inhalable dust was measured in stitching, button hall and special effect sections of the garment processing unit at mean dust levels of .603±.436 mg/m^3, .446±.257 mg/m^3 and .382±.174 mg/m^3 respectively. The exposed group was categorized into three groups having normal, obstructive and restrictive pattern of disease. This study provided evidence for relationship between exposure to cotton dust and other respiratory impairments without any association to smoking.

Key words: Prevalence, Byssinosis, Chronic Obstructive Pulmonary Diseases, Inhalable Dust, Spirometry and Workplace pollution.

(Received 26-05-2017 Accepted 18-09-2017).

INTRODUCTION

Workplace pollution is an important occupational problem in numerous industries causing occupational lung diseases which are documented on accounts of previous history (Monson, 1986). Industries, associated with the processing and handling of cotton specifically thread, yarn and fabric, are seen to be most associated with workers exposure to cotton dust (Kahraman *et al.*, 2013). The primary steps of textile processing release a greater amount of dust in the air and its long-term exposure can cause respiratory disorders among workers (Stellman, 1998). Through inhalation, small invisible cotton dust particles enter into the alveoli of lungs, which get accumulated in the lymph leading to reduction in the capacity to retain oxygen and ultimately causing damage to them (Pearce *et al.*, 2007). As a result of cotton dust accumulation, the workers get brown lungs and suffer from illness known as byssinosis (Baillargeon *et al.*, 1998). Industrial workplaces contaminated with cotton dust result in prolonged exposure along with substantial smoking habits have been proved to be significant risk factors to health of workers (Würtz *et al.*, 2014). Byssinosis is breathing disorder which occurs in individuals who are exposed to cotton, jute, flax and hemp. It is characterized by shortness of breath or chest tightness when a worker returns in a cotton processing enterprise for a day or so with cough of work week (Arrighi and Hertz-Picciotto, 1993).

Globally more than 62 million people are associated with textile sector (Sardanelli and Di Leo, 2009). The textile workers, who account for 38% of workforce of Pakistan, suffer from different workplace hazards causing pulmonary symptoms at manufacturing sites along with high cotton dust levels. None the less, not much is identified about the harmful effects caused due to cotton dust and endotoxins at cellular level (Boubopoulos *et al.*, 2010). Workers employed in the textile industry are exposed to various airborne particles, dusts having allergic, toxic, and infectious properties (Tadesse *et al.*, 2016). Occupational exposure to organic dusts such as cotton, flax, hemp, jute and various grains are held responsible for reversible pattern of asthma and chronic obstructive pulmonary disease (COPD) (Berry *et al.*, 1973).Technological maneuvers have changed work environment in the developed countries. Never the less, preventive measures in developing countries are far from being adequate (Malik *et al.*, 2010). Unfortunately, in Pakistan, there is no reliable data available about health hazards in textile sector. Therefore, the aim of this study was to measure the prevalence of respiratory symptoms and pulmonary function among workers of a garment manufacturing unit in Lahore and to study their association with demographic and environmental factors.

MATERIALS AND METHODS

There are different processes in the plant which produce a variety of cotton inhalable dust and fine suspended particles into workplace (Evans *et al.*, 2012). The study was approved by the code of ethics by University of the Punjab and a written consent of subjects was taken before trial in the month of February and March 2016. A modified version of questionnaire of the National Institute of Occupational Safety and Health (NIOSH) was used to elicit information on socio-demographic factors (Badesch *et al.*, 2010 and Nafees *et al.*, 2013) like gender, race, education, religion, ethnicity, marital status, income, residential status, job status, social security, smoking, job history, history of family respiratory ailment and cooking styles which were available in English, translated into national language (Urdu) and back translated into English to fetch healthy data.

Personal cotton dust sampling: Breathing zone cotton inhalable dust concentration was measured using a batch of twelve Apex Casella personal sampling pumps fitted with three piece assembly on 37mm polyvinyl filters containing SKC Aluminum cyclone, for about 7-8 hours in general shift in accordance with NIOSH recommended method No. 0600 (Hoek and Brunekreef, 1993). The filters were equilibrated for at least 2 hours in a non-vacuumed desiccator to remove moisture to maintain weight of samples. Mettler Toledo AS60/220.R2 analytical balance for weighing pre and post sampling filters was used (Lahiri *et al.*, 2005). The weight difference of post and pre sampling filters were corrected using variations in the field blanks. The personal sampling pumps were calibrated at an air flow rate of 2.5 L/min.

Sampling technique: According to the objectives, the researchers were unable to understand the behavior of the cotton dust exposure concentration. The concentration of the dust varied from section to section, firstly the concentration of the respirable dust was collected and the total sample for evaluation of the vulnerability was collected according to concentration of the said effect. Stratified random sampling technique was used to draw sample from the population when the problem of heterogeneous population was observed and strata were constructed on the basis of similarity. According to the situation stratified random sampling technique was applied to collect information from the textile unit due to heterogeneous population with regard to dust concentrations and population was divided into different strata. The textile unit comprised of 2045 subjects working in different sections. Each section was considered as a separate stratum with regard to dust concentration. Sample (respondents) were selected from each stratum (working sections) using simple random sampling within the strata with regard to size of working department ascertained from rosters.

A total of 200 textile workers were enrolled in the study. Eleven of them did not join during trial due to private engagement and were on leave while 30 declined to show their consent. Out of 159, nine subjects could not perform the pulmonary function test and were excluded resulting into the trial of 150 subjects (75% participation rate). For control group, a total of 75 eligible identified individuals were contacted for interview, pulmonary function test and other socio-demographic characteristics of same age group of which 50 were successfully taken and interviewed, yielding an overall control response rate of 66.6%. Twenty five controls were excluded from the study because they could not join the study. Control group subjects were selected from the working offices and students from a university and did not have cotton dust or other workplace chemical exposure in routine life.

Pulmonary function measurements: Pulmonary function tests were performed according to American Thoracic Society (ATS) criteria whilst the workers in standing and upright position using a portable Vitalograph 2120 with Spirotrac V software (Spirometry, 2003). The height (cm) without shoes and weight (kg) of the subjects wearing light cotton safety dress were measured using medical weighing balance. The instrument was calibrated using standard Vitalograph 1 Liter precision syringe. A minimum of three satisfactory forced expiratory manoeuvers were required of each subject. Workers were asked to refrain from smoking for at least 1 hour before performing the test and directed to a test room isolated from the work area. For each of the participant, vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), forced vital capacity ratio (FEV_1/FVC) and forced expiratory flow $FEF_{(25\%-75\%)}$ were measured. Analysis of the lung function variables were carried out on best of three values taken as percentage of predicted values. The workers were classified as smoker, non-smokers and ex-smokers. The criterion for smoking was defined as pack year which was determined as twenty tobacco sticks per day for a year (Lee and Schwartz, 1999). Do you now smoke daily, some days or not at all, were defined as current smokers. Ex-smoker were defined as those who had quit smoking $\geq$ 5 years (Liu *et al.*, 2015). Cough and phlegm were defined as cough or phlegm for 3 consecutive months for at least two years. Whistling sounds from chest with or without cold for at least two years was characterized as wheezing were incorporated in the questionnaire. Asthma was discussed as self-reported or physician diagnosed. Byssinosis was defined according to criteria set by (Schilling *et al.*, 1955) while breathlessness as walking sluggishly in comparison to co-workers or shortness of breath whilst using stairs. The following criteria was used for interpretation of lung function based on percentage predicted pulmonary volume.

- In the first category, individuals with measured FEV_1/FVC ratio greater than 0.7, FVC and FEV_1 values greater than 80% predicted, were considered normal.
- In second category, the individuals with measured FEV_1/FVC below 0.7 and FEV_1 less than 80% predicted were considered having obstructive pattern.
- Third category consist of subjects with measured FEV_1/FVC values greater than 0.7 and FEV_1, FVC less than 80% predicted were considered restrictive pattern.
- Fourth category comprised of the combination of last two categories.

In data analysis, considering the assumption of normality suitable test for analysis from parametric and non-parametric was adopted. Shapiro-wilk test for conformity of normality and Mann Whitney test for comparison among the groups in case of non-normality were used. Prevalence of respiratory ailment, lung function symptoms and association among personal exposure were analyzed using Pearson's correlation. The statistical analysis was performed using the statistical package program IBM SPSS software Statistics version 22.0.

RESULTS AND DISCUSSION

Section-wide distribution of cotton inhalable dust: Personal sampling was done to measure time-weighted average of exposure to cotton dust in different sections of the unit. The highest cotton dust concentration was recorded in stitching (0.603±0.436 mg/m^3) and lowest in finishing sections (0.0003±0.0001 mg/m^3). Likewise the cotton inhalable dust concentration in cutting, button hall, special effect, embroidery & screen printing, trimming, over-lock, washing, product development and administration sections were (0.281±0.145 mg/m^3), (0.446±0.257mg/m^3), (0.382±0.174 mg/m^3), (0.355±0.97 mg/m^3), (0.308±0.002 mg/m^3), (0.0003±0.001 mg/m^3), (0.325±0.066 mg/m^3), (0.348±0.102 mg/m^3) and (0.191±0.053 mg/m^3) respectively, as mentioned in table-1 with total number of subjects whose personal exposure to cotton dust were noted. Almost half of the sample i.e. 73(49%) of the workers were from stitching and trimming sections.

One hundred and fifty garment textile workers with at least one year work experience were selected for trial. Among them 128(85.3%) were males and 22(14.7%) were females having mean age of 33.23±9.08 years with employment duration of 7.31±5.83 years, while the control group comprised of males (100%) with a mean age of 30.18±10.54 years. The demographics, smoking habits and respiratory symptoms among the two groups are presented in table-2. Among the exposed groups 34% were reported were having phlegm and other respiratory symptoms like cough, wheezing and dyspnea (shortness of breath) which were 52%, 18% and 29% respectively. Six (4%) individuals were self-reported to have asthma from their childhood. Major (71.34%) part of the workforce under study was non-smoker while 43 (28.66%) were current smoker. In the control group, 10% of the subjects were having phlegm while prevalence of other respiratory symptoms such as wheezing, cough and dyspnea was 4%, 18% and 18% respectively. The overall, participants in the control group were young and non-smokers (74.4%), showing less respiratory illnesses in comparison to the exposed group. None of the subjects were ex-smokers. The subjects in the study were categorized into two groups *i.e.* those with employment duration of more than five years and the others less than five years.

Individuals with employment duration greater than 5 years were 94(62%) among them 48(51%) had normal lung function values, 7(7.5%) showed obstructive, 20(21.3%) restrictive while 19 (20.2%) showed mixed pattern. On the other hand, individuals with employment duration less than 5 years were 56(38%) among them 31(55%) were normal, 5(9%) were obstructive, 9(16%) showed restrictive lung diseases and 11(20%) has mixed pattern as shown in table-3.

In the study, both absolute and percentage values of the lungs function indicating the same results were analyzed and for the sake of scarce volume only the absolute values analysis was presented. After analyzing the results of lung functions of workers it was noted that younger the worker higher the lung capacity when compared with older.

The boxplot of the MFVC, $MFEV_1$, $MFEV_1/MFVC$ ratio and $MFEF_{(25-75)\%}$ in accordance with average concentration of cotton dust presented in figure-1 showed that the said factor resulted in lung impairment. It is evident that distribution of lung function was different from each other indicating the different aspects of vulnerability dispersion pattern among the subjects. Employees working in the industry for more than 5 years showed reduction in the pulmonary function values. Negative correlation was observed between change in FVC, FEV_1, FEV_1/FVC ratio, $FEF_{(25-75)\%}$ and cotton dust as (r= -0.138), (r= -0.10), (r= -0.036), and (r= -0.057) respectively showing reduction in pulmonary function indices with an increase in cotton dust concentration (Aminian *et al.*, 2013) as depicted in Table-4.

Table 1: Descriptive statistics (including Mean ±SD) of cotton dust concentration in different sections of a garment processing unit.

Sr. No.	Section	Cotton Dust Concentration (mg/m^3)	No. of samples of personal exposure
1	Cutting	0.281±0.145	11(7.33%)
2	Stitching	0.603±0.436	39(26%)
3	Button Hall	0.446±0.257	7(4.66%)
4	Special Effect	0.382±0.174	20(13.33%)
5	Embroidery & Screen Printing	0.355±0.97	3(2%)
6	Trimming	0.308±0.002	34(22.66%)
7	Over-lock	0.0003±0.001	5(3.33%)
8	Washing	0.325±0.066	11(7.33%)
9	Finishing	0.0003±0.0001	4(2.67%)
10	Product Development	0.348±0.102	10(7%)
11	Administration	0.191±0.053	6(4%)

Table 2: Descriptive statistics (Mean ±SD, frequency & percentage) and respiratory symptoms among the exposed and unexposed groups.

Variables	Exposed group	Unexposed group
N	150	50
Mean age (±SD)	33.23±9.08	30.18±10.54
No. of male	128(85.33%)	50(100%)
No. of female	22(14.66%)	----
Smoker	43(28.66%)	13(25.6%)
Non-smoker	107(71.33%)	37(74.4%)
Cigarette (per-day)*	7.66±6.37	4.9±5.99
Employment duration (years)	7.31±5.83	---
Cough	78 (52%)	9(18%)
Wheezing	27 (18%)	2(4%)
Dyspnea (shortness of breath)	44 (29%)	9(18%)
Phlegm	51 (34%)	5(10%)
Asthma	6(4%)	0

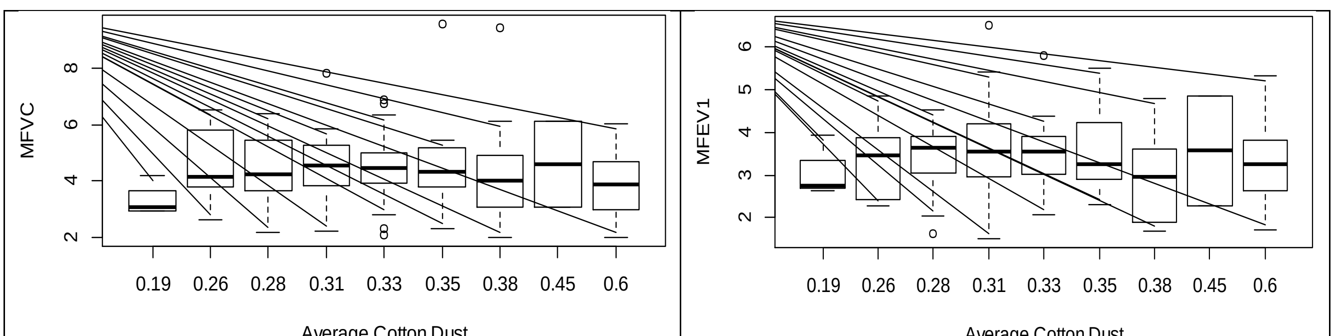
*significant at $\alpha = 0.05$

Table 3: Descriptive statistics (including Mean ±SD) and significance level of PFT of the exposed and control groups showing decline in pulmonary function indices.

Categories	Variables	Exposed Group	Control Group	P- value
Normal	FVC (L)	4.09 ±0.96	4.69 ±0.90	0.001
	FEV_1 (L/sec)	3.21 ± 0.81	3.91 ±0.78	0.002
	FEV_1/FVC (%)	79.02 ± 12.95	83.34 ±0.06	0.015
	$FEF_{(25-75\%)}$ (L/sec)	3.11 ± 1.74	4.32±1.70	0.001
Obstructive	FVC (L)	3.84 ±0.99	4.09 ± 0.96	0.424*
	FEV_1 (L/sec)	2.28 ±0.45	3.21 ± 0.81	0.001
	FEV_1/FVC (%)	60.42 ±0.06	79.02 ± 12.95	0.001
	$FEF_{(25-75\%)}$ (L/sec)	0.94 ±0.72	3.11 ± 1.74	0.001
Restrictive	FVC (L)	2.78±0.55	4.09 ± 0.96	0.001
	FEV_1 (L/sec)	2.38 ±0.44	3.21 ± 0.81	0.001
	FEV_1/FVC (%)	86.28 ±0.07	79.02 ± 12.95	0.009
	$FEF_{(25-75\%)}$ (L/sec)	2.84 ±0.97	3.11 ± 1.74	0.468*

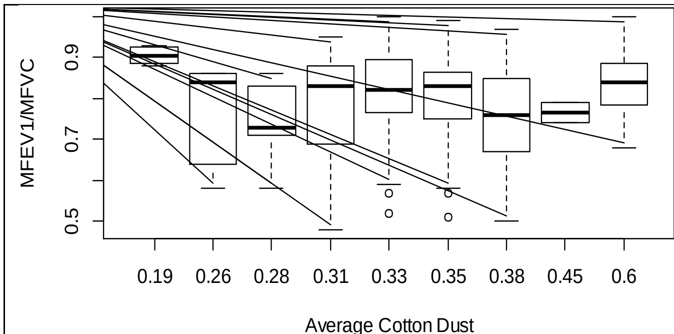
*P-values indicates insignificance at $\alpha = 0.05$.

Table-3 indicated the comparison of vulnerability among both exposed and control groups. It could be observed from the comparison that exposed group was facing higher vulnerability in comparison to control group.

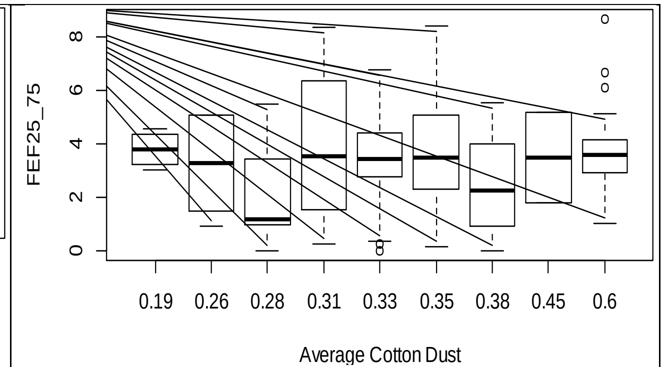


a: Boxplot between MFVC and Average Cotton Dust

b: Boxplot between $MFEV_1$ and Average Cotton Dust



c: Boxplot between $MFEV_1/MFVC$ and Average Cotton Dust



d: Boxplot between FEF_{25-75} and Average Cotton Dust

Figure 1: Boxplot of the lung function with regard to inhalable average cotton inhalable dust

Table 4: Correlation Structure among Pulmonary Function Test (PFT) values and Multiple Variables.

Correlations Structure		Year Worked	Age	Height	Weight	cotton dust	FVC Measured	FEV_1 Measured	FEV_1/ FVC Measured	FEF_{25-75} Measured
Year Worked	Pearson Correlation	1	.458**	0.153	0.192	0.018	0.111	0.047	-0.097	-0.093
	P-value		0	0.175	0.087	0.874	0.326	0.676	0.393	0.411
Age	Pearson Correlation	.458**	1	-0.138	0.206	-0.067	0.138	0.138	0.051	0.081
	P-value	0		0.221	0.067	0.555	0.221	0.223	0.654	0.476
Height	Pearson Correlation	0.153	-0.138	1	.356**	.317**	-0.089	-0.003	0.129	-0.046
	P-value	0.175	0.221		0.001	0.004	0.433	0.982	0.254	0.686
Weight	Pearson Correlation	0.192	0.206	.356**	1	0.205	-0.041	-0.014	0.01	-0.059
	P-value	0.087	0.067	0.001		0.069	0.721	0.903	0.932	0.605
Cotton Dust	Pearson Correlation	0.018	-0.067	.317**	0.205	1	-0.138	-0.1	-0.036	-0.057
	P-value	0.874	0.555	0.004	0.069		0.221	0.377	0.752	0.613
FVC Measured	Pearson Correlation	0.111	0.138	-0.089	-0.041	-0.138	1	.840**	-0.201	.296**
	P-value	0.326	0.221	0.433	0.721	0.221		0	0.074	0.008
FEV_1 Measured	Pearson Correlation	0.047	0.138	-0.003	-0.014	-0.1	.840**	1	.344**	.729**
	P-value	0.676	0.223	0.982	0.903	0.377	0		0.002	0
FEV_1/FVC Measured	Pearson Correlation	-0.097	0.051	0.129	0.01	-0.036	-0.201	.344**	1	.778**
	P-value	0.393	0.654	0.254	0.932	0.752	0.074	0.002		0
FEF_{25-75} Measured	Pearson Correlation	-0.093	0.081	-0.046	-0.059	-0.057	.296**	.729**	.778**	1
	P-value	0.411	0.476	0.686	0.605	0.613	0.008	0	0	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

In this study, respiratory symptoms of workers of textile processing unit located in the center of the city were explored. It was generally recognized that exposure to cotton dust in textiles was associated with byssinosis and other respiratory ailments and workers were more prone to them (Cui *et al.*, 2011). These symptoms are important causes of morbidity among them. The enterprise was not good enough to illustrate the picture of situation of occupational health and safety at workplace and there were no signs of good housekeeping as noted by the authors (Nafees *et al*., 2013). The workers in this textile facility were reasonably of same composition with regard to education, race, religion, marital status, housing facilities and other socio-demographic characteristics. Most of the workers were Punjabi and had experience of only one job throughout their professional career.

A number of research studies proved that cotton textile workers had more chronic cough, chronic bronchitis and decrement in FVC and FEV_1 than controls. In a research study, the prevalence of respiratory characteristics among exposed workers were higher in comparison to control while the studies carried out by Nafees *et al.* (2013) and (Mitchell *et al.*, 2015 and Astrakianakis *et al.*, 2007) showed opposite results. In present study, there was a clear indication that exposed groups had higher chronic respiratory symptoms as compared to control group. The occupational asthma was commonly found among textile workers with the prevalence of 14.5 % in case studies by (Zock *et al.*, 1998). None of the subjects complained about workplace asthma in this study. Anyhow, 4 percent of the subjects complained about asthma in their childhood present study which was reported in Pakistan by (Nafees *et al*., 2013 and Farooque *et al.*, 2008).

Duration of work exposure ≥5 years was associated with shortness of breath as well as drop in lung function seen after adjusting for age, height and other covariates reported by (Tanzil and Nafees, 2015). It was also found during data analysis that trimming and sewing sections of the textile unit were deeply associated with respiratory symptoms, showing wheeze, chronic wheeze and chest tightness which was comparable with studies carried out by (Tanzil and Nafees, 2015; Nafees *et al*., 2013 and Farooque *et al*., 2008). In these sections obstructive pattern of lung function was observed and the concentration of cotton dust was also high. Anyhow, preventive measures were warranted in order to develop safety and health culture at workplace to reduce high prevalence of respiratory disorders in garment industry. COPD was the main cause of morbidity and mortality around the globe and its prevalence was linked to workplace exposures and cigarette smoking. The COPD pattern was also found higher in exposed worker in comparison to control group. The detrimental effects of cotton dust exposure were less in non-smokers than smokers. The above mentioned studies proved that occupational exposures like organic dust were the causes of irreversible obstruction of airflow. In this study impact of cotton dust on textile workers, office staff, university department staff and students as control was observed. It was also recognized that exposure to organic dust was a reason for respiratory inflammation which lead to development of chronic respiratory symptoms and loss to lung function. The prevalence of COPD in significant manner among the exposed group and this was in agreement with the studies narrating deep link between cotton dust exposure and COPD progression.

Many studies have proved harmful effects of smoking among workers of textile and other occupations. Anyhow, this study did not show any deleterious effects on lung function indices among smokers due to which it cannot infer about additive association by smoking. One of the possibilities of having no relation of smoking for adverse effect might be that smoking was very common among healthier and younger individuals and they kept it continued as long as they were alive. The other possibility of not showing any adverse effect was due to young population with mean age of 33.23±9.03 years, often termed as healthy smoker selection. The strengthening factors for the study were using standardized procedures developed by NIOSH, ATS guidelines reducing any chance of error in the procedure reported by (Centurion *et al.*, 2012). According to the criteria at least three acceptable attempts were made for each worker in the study to escape poor technique factor (Zwar *et al.*, 2011).

In textile sector a number of chemicals were used in processes like dyeing and washing and even dyed stuff contained dyes, residues of pesticides, endotoxin level and other toxic compounds which were highly hazardous which caused respiratory problems leading to increased risk of COPD among cotton textile workers (Singh and Chadha, 2013). The concentrations of endotoxins were higher in the textile processing units, therefore, workers employed in this sector of economy were more likely to suffer from byssinosis (Centurion *et al.*, 2012) and other sectors like agriculture (Reynolds *et al.*, 2012; Cui *et al.*, 2011) and wood trimmers (Jacobsen *et al.*, 2010). Prevalence of COPD increased with age and smoking history, but other factors like history of lung tuberculosis, some socio-demographics like in-house biomass smoke exposure, exposure to fumes, air pollution and chronic asthma were also thought to be important factors in explaining the variations. There is a dire need to work on this direction to study the effects of aforementioned factors on health of textile worker.

Conclusion: In this cross-sectional study, lungs impairment with regard to cotton dust was observed which was independent of smoking among subjects and control group. Prevalence of COPD among them was also observed.

REFERENCES

Aminian, O., A. Mozafari, K. S Haghighi, F. Chavoshi, M. Saraie and N. Izadi. (2013) Study of respiratory symptoms and pulmonary function in cotton textile workers. J. Basic. Appl. Sci. Res. 3: 33-36.

Arrighi, H.M. and I. Hertz-Picciotto. (1993) Definitions, sources, magnitude, effect modifiers, and strategies of reduction of the healthy worker effect. J. of occup. and environ. med. 35:890-891.

Astrakianakis, G., N.S. Seixas, R. Ray, J.E. Camp, D.L. Gao, Z. Feng, W. Li, K.J. Wernli, E.D. Fitzgibbons and D.B. Thomas (2007) Lung cancer risk among female textile workers exposed to endotoxin. J. of the Nation. Canc. Inst. 99: 357-364.

Badesch, D.B., G.E. Raskob, C.G. Elliott, A.M. Krichman, H.W. Farber, A.E. Frost, R.J. Barst, R.L. Benza, T.G. Liou and M. Turner (2010) Pulmonary arterial hypertension: baseline characteristics from the reveal Registry. Chest. J. 137: 376-387.

Baillargeon, J., G. Wilkinson, L. Rudkin, G. Baillargeon and L. Ray (1998) Characteristics of the healthy worker effect: a comparison of male and female occupational cohorts. J. of occup. and environ. med. 40: 368-373.

Berry, G., C. McKerrow, M. Molyneux, C. Rossiter and J. Tombleson (1973) A study of the acute and chronic changes in ventilatory capacity of workers in Lancashire cotton mills. Brit. J. of indust. med. 30: 25-36.

Boubopoulos, N.J., T.C. Constandinidis, M.E. Froudarakis and D. Bouros (2010) Reduction in cotton dust concentration does not totally eliminate respiratory health hazards: The Greek study. Toxic. and indust. health. 26: 701-707.

Brusasco, E.V., R. Crapo, G. Viegi, J. Wanger, J. Clausen, A. Coates, O. Pedersen, V. Brusasco, F. Burgos and R. Casaburi (2005) Series ‘‘ATS/ERS task force: standardisation of lung function testing’’.

Centurion, V.P., F. Huang, E.T. Naureckas, C.A. Camargo Jr, J. Charbeneau, M.J. Joo, V.G. Press and J.A. Krishnan (2012) Confirmatory spirometry for adults hospitalized with a diagnosis of asthma or chronic obstructive pulmonary disease exacerbation. B. M. C. pulmon. med. 12: 1.

Cui, L., L.G. Gallagher, R.M. Ray, W. Li, D. Gao, Y. Zhang, S. Vedal, D.B. Thomas and H. Checkoway (2011) Unexpected excessive chronic obstructive pulmonary disease mortality among female silk textile workers in Shanghai, China. Occup. and environ. med. 68: 883-887.

Evans, D.E., L.A. Turkevich, C.T. Roettgers, G.J. Deye and P.A. Baron (2012) Dustiness of fine and nanoscale powders. Annals. of Occup. Hyg. 060.

Farooque, M.I., B. Khan, F. Aziz, M. Moosa, M. Raheel, S. Kumar and F.A. Mansuri (2008) Students' Corner-Byssinosis: As seen in cotton spinning mill workers of Karachi. JPMA. The J. of the Pak. Med. Assoc. 58: 95.

Hoek, G. and B. Brunekreef (1993) Acute effects of a winter air pollution episode on pulmonary function and respiratory symptoms of children. Arch. of Environ. Health: An Intern. J. 48: 328-335.

Jacobsen, G., I. Schaumburg, T. Sigsgaard and V. Schlunssen (2010) Non-malignant respiratory diseases and occupational exposure to wood dust. Part II. Dry wood industry. Annals. of Agri. and Environ. Med. 17: 29-44.

Kahraman, H., M.H. Sucakli, T. Kilic, M. Celik, N. Koksal and H.C. Ekerbicer (2013) Longitudinal pulmonary functional loss in cotton textile workers: A 5-year follow-up study. Medical science monitor: Intern. med. J. of experim. and clin. research. 19: 1176.

Lahiri, S., C. Levenstein, D.I. Nelson and B.J. Rosenberg (2005) The cost effectiveness of occupational health interventions: prevention of silicosis. Amer. J. of indust. med. 48: 503-514.

Lee, J.-T. and J. Schwartz (1999) Reanalysis of the effects of air pollution on daily mortality in Seoul, Korea: A case-crossover design. Environ. Health. Persp. 107: 633.

Liu, Y., R.A. Pleasants, J.B. Croft, A.G. Wheaton, K. Heidari, A.M. Malarcher, J.A. Ohar, M. Kraft, D.M. Mannino and C. Strange (2015) Smoking duration, respiratory symptoms, and COPD in adults aged≥ 45 years with a smoking history. Intern. J. of chron. obstruct. pulmon. disease. 10: 1409-1416.

Malik, N., A.A. Maan, T.S. Pasha, S. Akhtar and T. Ali (2010) Role of hazard control measures in occupational health and safety in the textile industry of Pakistan. Pak. J. Agri. Sci. 47: 72-76.

Mitchell, D.C., T.L. Armitage, M.B. Schenker, D.H. Bennett, D.J. Tancredi, C.E. Langer, S.J. Reynolds, G. Dooley, J. Mehaffy and F.M. Mitloehner (2015) Particulate matter, endotoxin, and worker respiratory health on large Californian dairies. J. of occup. and environ. med. 57: 79-87.

Monson, R.R. (1986) Observations on the healthy worker effect. J. of occup. and environ. med. 28: 425-433.

Nafees, A.A., Z. Fatmi, M.M. Kadir and N. Sathiakumar (2013) Pattern and predictors for respiratory illnesses and symptoms and lung function among textile workers in Karachi, Pakistan. Occup. and environ. med. 70:99-107.

Pearce, N., H. Checkoway and D. Kriebel. (2007) Bias in occupational epidemiology studies. Occup. and environ. med. 64: 562-568.

Reynolds, S.J., M.L. Clark, N. Koehncke, S. Von Essen, L. Prinz, T.J. Keefe, J. Mehaffy, M. Bradford, B. Cranmer and M.E. Davidson (2012) Pulmonary function reductions among potentially susceptible subgroups of agricultural workers in Colorado and Nebraska. J. of occup. and environ. med. 54: 632-641.

Sardanelli, F. and G. Di Leo (2009) Non-parametric statistics. Biostatistics for Radiologists: Planning, Performing, and Writing a Radiol Study 93-108.

Schilling, R., J. Hughes, I. Dingwall-Fordyce and J. Gilson (1955) An epidemiological study of byssinosis among Lancashire cotton workers. Brit. J. of Indust. med. 12: 217.

Singh, Z. and P. Chadha (2013) Genotoxic effect of fibre dust among textile industry workers. J. of Environ. Sci. and Sustain. 1: 81-84.

Spirometry, N. (2003) NIOSH Spirometry Training Guide.

Stellman, J.M. (1998) Encyclopaedia of occupational health and safety. Intern. Labour. Organ.

Tadesse, S., T. Kelaye and Y. Assefa (2016) Utilization of personal protective equipment and associated factors among textile factory workers at Hawassa Town, Southern Ethiopia. J. of Occup. Med. and Tox. 11: 1.

Tanzil, S. and A.A. Nafees (2015) Low prevalence of asthma among textile workers in Karachi, Pakistan. The J. of the Pak. Med. Assoc. 65: 869-874.

Würtz, E.T., T.B. Aasen, M.R. Miller and S. Viskum (2014) Occupational chronic obstructive pulmonary disease: a systematic literature review. Scand. J. of work. environ. and health. 40: 19.

Zock, J.-P., D. Heederik and G. Doekes (1998) Evaluation of chronic respiratory effects in the potato processing industry: indications of a healthy worker effect? Occup. and environ. med 55: 823-827.

Zwar, N.A., G.B. Marks, O. Hermiz, S. Middleton, E.J. Comino, I. Hasan, S. Vagholkar and S.F. Wilson (2011) Predictors of accuracy of diagnosis of chronic obstructive pulmonary disease in general practice. Med. J. Aust. 195: 168-171.