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Lungs function in relation to exposure to cotton dust in a Hosiery section of a Textiles Plant in Punjab, Pakistan

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This study aimed at determining whether exposures to organic dusts were associated with decreases in lungs function among workers exposed to cotton dust in a hosiery unit manufacturing pure cotton garments. In a cross-sectional study, 287 employees underwent lungs function testing in accordance with the National Institute of Occupational Safety and Health (NIOSH) spirometric guidelines. Workers were selected with the help of stratified random sampling of age 19–50 years (participation rate 82.0%). A modified NIOSH questionnaire was used to elicit information from them. We also measured personal dust and fine particulates (aerodynamic diameter of 2.5 micron and less, $PM_{2.5}$) in the working areas near the workers, and these pollutants were measured using a personal dust sampler and a DustTrak™, respectively. Concentrations of total dust and $PM_{2.5}$ varied among the different areas of a hosiery plant. The deleterious effects of cotton dust were higher in smokers than non-smoker workers. An association between exposures to cotton dust and to $PM_{2.5}$ and lungs function in the study population were found. This study shows association with lungs function arising from exposure to organic dust and $PM_{2.5}$.

Keywords: Exposure, Prevalence, Lungs Function, $PM_{2.5}$, Socio-demographic

INTRODUCTION

The textile industry is the second largest industry in the world (Nisar et al.2013), and is the most important manufacturing sector in Pakistan. The textile industry in Pakistan employs approximately 40% of workforce and contributes importantly to the economy. Around 15 million people (about 25 per cent of the workforce) are employed in this sector. Textile units are concentrated in Karachi, Faisalabad and Lahore. There are total 464 textile units in Pakistan, out of which 316 textile units exist in the Punjab (Pakistani textile sector, 2022). The employed workforce is mainly poor, un-educated and contractual from the suburban rural areas of the textile units. Most of the workers are un-registered, socially unsecured and working in shifts round the clock. The sector comprises cotton ginning, spinning, fabric, processing, dyeing yarn, and fabric, made-ups like hosiery and knitwear, towels, tents and canvas, bed wear, cotton bags, and the fabrication of garments (Pakistan Economic Survey, 2022). At present, there are 3,500 large, medium and small hosiery units, 85% of them are small units, 10% medium and only 5% large composite hosiery and knitwear units in Pakistan. Organic dusts exposure may cause acute or chronic respiratory signs and symptoms often come with change in lung function. (Post et al. 1998). Cotton dust is generated in variable concentrations throughout the various textile processes (Nafees et al. 2013). A study conducted among Lancashire textile workers found that smoking was significantly associated with respiratory impairment (Raza et al. 1999). It has long been known that textile workers can be exposed to very high airborne concentrations of particulate matter from natural and synthetic fibers (Sharma et al. 2014). Cotton dust is known to cause respiratory illnesses (Khan and Nanchal, 2007) including asthma, chronic bronchitis, bronchial hypersensitivity (Jacobson et al. 2013) and byssinosis (Wang et al. 2004). Exposures to cotton dust, according to cross-shift studies, can cause reversible narrowing of the airways, as demonstrated by exposures to cotton dust causing decreases in FEV_1 and other lung function parameters (Su et al. 2003). In addition to decreased forced expiratory volume in one second (FEV_1), increased reactivity to the airways, as measured by the methacholine challenge test, may occur after acute or repeated exposure to cotton dust (Merchant et al 1975).

Numerous studies have indicated that cotton textile workers have a higher prevalence of respiratory symptoms and greater decreases in lung function compared with the general population and with other textile workers (Cui et al. 2011). An association between cross-shift decrements in lung function indices and subsequent decline in lung function has been found in other industries comprising wood trimmers (Dahlqvist and Ulfvarson, 1994) grain workers (Chan et al. 1981), coal miners, coffee, tea, spices, and animal food related to exposure to mold spores, grain dust, coal dust, and end toxins. Lung diseases that result from occupational exposures are most likely caused by the inhalation of dust and deposition of inhaled particles which may initiate local inflammatory processes in the air ways and lungs (Wurtz, 2014). Other potential respiratory hazards in the textile industry include wool dust, silk dust, synthetic fibers, finishing agents, bleaches, and highly acidic or basic chemicals. Cigarette smoking is a key lifestyle factor that affects respiratory health (Hochgatterer et al. 2013). The workers spend a considerable amount of time at their workplace during duty hours and are exposed to indoor dirty/noisy climate prevailing in the workplaces (Tahir et al. 2012).

Modernization of the cotton industries in developed countries has led to improved working environments (Memon et al. 2008). However, working conditions has not improved in developing countries and exposures can be quite high and subsequently large numbers of textile workers may be suffering from respiratory illnesses. Lack of government regulations, improper system of factory inspection and economic forces to maximize profits have obstructed improvement in industrial hygiene. Exposure to cotton dust in the textile industry adds considerably to the occupational burden of disease globally, and the burden of respiratory diseases is high in Pakistan (Yusuf, 2009). However, there is paucity of data on the respiratory health of textile workers in Pakistan. Most of the available studies are questionnaire-based, and have methodological limitations, such as inadequate sample size, thus limiting their representativeness. This study aims to investigate harmful effects of cotton dust on respiratory health of workers in a hosiery processing unit in Punjab, Pakistan.

MATERIALS AND METHODS

This cross-sectional study was carried out in 2019 in the hosiery section of a textiles plant in Faisalabad, Pakistan, using simple random sampling without replacement using sampling frame generated by factory workers list. It is often observed that factories in Pakistan bearing high rate of turnover of workers in textiles sector and many are on day-to-day contractual work, it was decided to focus attention on the 3,056 permanent workers of the facility. These workers were male as high portion of them employed in different divisions, including spinning, yarn manufacturing, and hosiery. It is a universal phenomenon; males are dominant in every walk of life. Likewise, Pakistani society is also male dominant. Of these, 350 worked in the hosiery division and it was in this sub-population that the present study was conducted. Fifteen workers refused to participate in the study, leaving 335 subjects; 29 could not participate due to issues in work shift rotation, absenteeism and workload. Thus, the number of participants under study was 306 and the participation rate was 82.0%. In addition, 19 subjects had incomplete lung function data and they were excluded from the analyses, thus leaving 287 workers in the analysis.

A modified version of the NIOSH questionnaire (Merchant et al. 1986) was used to elicit information on socio-demographic factors. The modifications included changing questions on education, religion, ethnicity, marital status, residential status, job status, social security, and cooking style to reflect the local culture of this area of Pakistan. Highly qualified and trained technicians administered the questionnaire. Lung function tests were conducted using a Vitalograph's portable spirometer model No. 2120 equipped with Spirotrack V™ software and standard procedures of calibration and measurements were adopted from the American Thoracic Society (ATS) (Division of consumer health education, 2003). All subjects performed the spirometry in a standing position and the maximum of three values for each of the subjects were used for evaluation. Vital Capacity (VC) Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV_1), percent values of VC, FVC and FEV_1 were obtained under standard explained conditions.

Measurement of $PM_{2.5}$ and total dust concentrations

$PM_{2.5}$ have larger surface area to volume relationship and carry high degree of toxic metals and acids and that make them capable to penetrate deeper into the respiratory tract from an aerodynamic perspective(Hussain et al. 2011). Additionally, after exposure these adverse effects can persist even for several weeks. There is ample evidence which suggest that $PM_{2.5}$ are linked with several health problems such as chronic respiratory disease, premature mortality, aggravated asthma, respiratory emergency room visits and hospital admissions, decreased lung function and respiratory symptoms (Prieditis and Adamson, 2002). Two sampling campaigns were conducted to measure cotton dust and fine particulates $PM_{2.5}$ (with aerodynamic diameters 2.5µm or less; $PM_{2.5}$) concentrations. Total dust was measured using personal monitors in the working area. Personal samples of dust for 81 workers were measured in four shifts which was performed to assess area-wide exposure to cotton dust by following gridline pattern for sampling during a period of one and half months (June to July, 2019). The areas selected for sampling were Administration/Environment Health and Safety section, Boiler section, Chemical lab, Finishing, Knitting, Mechanical workshop, Processing, Toe closing and Yarn dyeing of the facility.

The workers across working shifts from Monday to Saturday were considered, and they represented the conditions of other workers in the same working section because they all were working at the same workstation. There were two working shifts i.e., general and rotatory (comprising a general one from 8:00am to 4:00pm and rotatory covering morning shift from 6:00am to 2:00pm, evening shift from 2:00pm to 10:00pm, night or third shift from 10:00pm to 6:00am in the morning. Six Casella Apex Pro Personal Air Sampling Pumps were used in accordance with the National Institute of Occupational Safety and Health (NIOSH) recommended method 0500. In the factory, the sampling heads were clipped to the lapels of subjects, secured safely, and connected to Casella pumps (worn on the waist) for the duration of the full shift (7-8 hrs) and were not interrupted during lunch, tea or toilet use. The flow rate (1.7-2.0 Litres/min) was checked periodically with a flow meter. Thirty-seven mm poly-vinyl chloride pre-weighed filters were mounted in the cassettes inside the sampling head.

On return from the factory, the cassettes inside the sampling heads were opened and the filters were re-weighed to obtain the weight change by using a high-precision Mettler Toledo AT240 analytical balance (Mettler-Toledo Inc., Columbus, OH). A few sampling heads (blanks) were taken into the workplace just opened for a while, closed, re-desiccated and weighed after sampling. These blanks were treated like the active sampling heads for weighing before and after the visit. We used mean change in the weight of blanks as a correction factor. If positive, it was subtracted from (if the correction factor was negative, it was added to) the weight change of filters used for sampling to obtain the corrected weight change in the total dust sample. The level thus measured was termed total dust in the personal breathing zone of the operatives of working sections under study. Nine of 117 samples were tampered with by workers, 3 had no clear indication of information regarding sampling or mislabeled area-wise and three samples were left unattended and could not be analyzed, thus providing 102 samples for analysis.

Measurements of $PM_{2.5}$

$PM_{2.5}$ was measured in the same sections of the plant in which total dust was measured. We used the DustTrak™ Aerosol Monitor (Model No. 8520), which is easy to operate, portable and provide continuous output (Cambra-Lopez et al. 2012). The DustTrak™ is a real-time optical scattering instrument that measures particulate matter in the airflow and are shown to over report ambient urban $PM_{2.5}$ levels (Mcnamara et al. 2011). The DustTrak™ aerosol monitors were mounted on a tripod stand at the same height of 1.5 m above ground level in the breathing zone in each section of the enterprise near the workstations. The $PM_{2.5}$ sampling was carried out simultaneously along with personal dust sampling across the shifts for a duration of two to four hours. Ninety-seven samples of $PM_{2.5}$ were taken altogether, 9 samples were tampered with by the subjects, and the samples which had sampling durations of less than two hours were thus not considered for further study.

The procedure of the data entry comprised confirming accuracy of data entered by the data entry operator, identification of any duplicate entry and its removal, checking values between field information and reports of laboratory. Identified critical and non-critical errors in the data base were corrected. An error in sampling result (sample concentration, laboratory result or units) or (PM2.5 personal dust exposure or lung function) was considered critical.

The study was categorized in two ways, firstly for the categorical data analysis, descriptive analysis was provided, the association among lung diseases and cotton total dust and $PM_{2.5}$ was observed and the lung function decline was confirmed by independent samples t-test. Multivariate analysis was performed to observe additive effect of smoking with cotton total dust and $PM_{2.5}$ and a decline in lung function of subjects.

RESULTS

Table-1 shows the distribution of personal characteristics among the 287 workers (265 men; 22 women) participating in this study. The duration of employment at the plant ranged from one to twenty years. One hundred and sixty-nine workers worked for 1-5 years (mean 3.24 years), 90 worked for 6-10 years (mean 3.07 years), 24 had worked for 11-15 years (2.68 years) and rest of the workers for 16-20 years (2.20 years) in the same facility. None of the women were smokers and 22.65% men were current smokers and the 2 ex-smokers had quit more than 5 years ago were considered as non-smokers. Most of them had smoked for more than 5 years. Only 29 (10.1%) operatives had chronic cough lasting from one to ten years while 53 (18.47%) had phlegm. Eight (2.79%) operatives had problems with wheezing.

Among the workers 24(8.4%), 83(28.9%), 107(37.9%), 38(13.3%), 23(8%), 4(1.4%) and 8(2.8%) had completed their primary level, middle level, matric level, intermediate level, bachelor level, master and other (Hifz and diploma) level of education respectively. Two hundred and eighty four (97.9%) were Muslim and 3(1%) from Christian community, among them 281(97.9%) were Punjabi and rest of workers from other provinces.

Table 1: Selected characteristics of 287 participants working in the hosiery processing division of a textile unit.

Variable	Response	Frequency (%)
Gender	Female	22(7.67)
	Male	265(92.3)
Educational	Primary	24(8.4)
	Middle	83(28.9)
	Matric	107(37.9)
	Intermediate	38(13.3)
	Bachelor	23(8.0)
	Master	4(1.4)
	Other	8(2.8)
Job Status	Permanent	280(97.5)
	Contract	7(2.4)
Religion	Islam	284(99)
	Christian	3(1)
Race	Punjabi	281(97.9)
	Other	6(2.1)
Income(PKR)	5000-9999	146(50.9)
	10000-19999	124(43.2)
	20000-49999	15(5.2)
	50000-99999	2(0.7)
Insurance	Government Funding	277(96.5)
	Private Insurance	3(1.1)
	Both(Government & Private)	7(2.4)
Marital	Married	180(62.7)
	Divorced	2(.7)
	Open relationship	2(0.7)
	Other	6(2)
	Single	97(33.8)
Living status	Live with family	3(1)
	Owned	252(87.8)
	Rented	32(11.2)
Smoking status	Smoker (Male)	65(22.7)
	Smoker (Female)	0
	Never Smoker	222(77.3)
Chronic cough		29(10.1)
Phlegm		53(18.47)
Wheezing		8(2.79)

Ninety three percent of workers were reported drawing income from Rupees 8,000 to Rupees 20,000 (1US$ = 150 Pakistani Rupees) and majority of them using natural gas as fuel for cooking food. Majority of the worker (62.7%) were married while 97(33.8%) of them reported to be single, whereas 2(0.7%) each of them were divorced and had open relationships with the opposite sex, respectively. Most of the workers had their own residential facility (252) (87.8%) whereas only 32(11.2%) were living on rented residences.

Concentrations of $PM_{2.5}$ and total dust in the workplace

The distributions of cotton total dust levels and $PM_{2.5}$ are shown in Table-2. Operatives in knitting hall and mechanical workshop as well as in finishing area were exposed to high levels of cotton total dust with mean dust levels of 0.91 mg/m^3, 0.88 mg/m^3 and 0.65 mg/m^3, respectively. $PM_{2.5}$ values ranged from 0.32 mg/m^3 to 1.01 mg/m^3 in different sections of the enterprise under study with lowest in the Administration/EHS (Environment health and safety section) department and highest in yarn dyeing section. The high $PM_{2.5}$ values in Administration/EHS department was reported to the management and it was found that central air conditioning system was mal-functioning while in the Mechanical workshop the work done was dusty and rough. All samples in these areas had total dust levels below 10 mg/m^3, ranging from 0.13 mg/m^3 to 0.91 mg/m^3. Workers in the processing, administration/EHS (Environment Health and Safety section) areas as well as in the toe closing area were exposed to high level 0.53 mg/m3, 0.52 mg/m3 and 0.53 mg/m^3, of cotton dust respectively. The cotton dust levels in the chemical lab and boiler areas were relatively low (0.24 mg/m^3 and 0.13 mg/m^{3}respectively).

Table-3 showed comparison of measured respiratory symptoms with the predicted and explains the average level of the functions under comparison grouped according to different factors such as smoking, cough and phlegm. After observing normality of the data, it was observed that smoking has significant effect in lung impairment and had additive effects in their impairment as well. The following relation was applied in calculating percent change.

$$\mathrm{PC} = 100 - \left(\frac{\text{the mean having symptoms of PFT}}{\text{the mean having no symptoms of PFT}} \times 100\right)$$

The percent change measures the percent of lung impairment with regard to subjects having no symptoms as for significant factor positive change is observed indicating lung impairment which may be explained as person who smoked has eight percent lung impairment than subject who do not smoked as the occurrences of reduced lung function in smokers was large than those of nonsmoker. The concentration level of cotton dust and $PM_{2.5}$ was categorized into two groups i.e., below and above 0.5 mg/m^3 in different sections of the enterprise. It was noted that the number of subjects with chronic cough, phlegm and wheezing was higher than those working in less dust concentration level. A similar trend was also observed in cotton dust exposure to cough phlegm and wheezing (Table 4).

When observing effect of smoking it was noted that ratio of respiratory symptoms was increased among the workers indicating synergistic effect of smoking with respect to cotton and $PM_{2.5}$ exposure (Table-5).

Table 2: Distribution of concentrations of cotton dust and $PM_{2.5}$ in different sections of hosiery division of the textile plant.

Section	No. of subjects	Mean total dust (mg/m^3)	Range	No. of samples	Average $PM_{2.5}$ (mg/m^3)	Range	No. of Samples
Administration/EHS	4	0.53	0.19-0.60	5	0.32	0.11-0.89	3
Boiler section	2	0.13	0.12-0.29	4	0.43	0.24-0.99	4
Chemical lab	12	0.24	0.091-0.49	8	0.45	0.09-0.75	8
Finishing	12	0.65	0.28-0.99	7	0.46	0.12-0.59	8
Knitting	25	0.91	0.43-2.57	12	0.49	0.06-0.71	11
Mechanical workshop	23	0.88	0.54-1.96	9	0.61	0.21-1.15	8
Processing	141	0.53	0.13-3.01	16	0.84	0.31-1.02	21
Toe closing	32	0.54	0.10-0.25	11	1.01	0.81-1.24	12
Yarn dyeing	36	0.65	0.152-1.78	9	1.02	0.62-1.5	13
Total number of samples				81			88

Table 3: Respiratory symptoms and impaired lungs function with respect to different factors.

Factors	PFT	Yes	No	P-value	PC
Smoker	MVC	2.676	2.895	0.034	7.559
	MFVC	2.987	3.247	0.024	7.986
	MFEV1	2.479	2.618	0.110	5.304
	$MFEV_1$/MFVC	0.701	0.824	0.049	14.888
Cough	MVC	2.821	3.277	0.005	13.910
	MFVC	3.167	3.523	0.031	10.102
	$MFEV_1$	2.578	2.759	0.280	6.568
	$MFEV_1$/MFVC	0.773	0.807	0.008	4.305
Phlegm	MVC	2.976	2.848	0.661	-4.489
	MFVC	3.157	3.191	0.914	1.070
	$MFEV_1$	2.386	2.593	0.383	7.982
	$MFEV_1$/MFVC	0.727	0.807	0.029	9.873

Table 4: Exposure of cotton dust, $PM_{2.5}$ and smoking on respiratory symptoms.

Respiratory Symptoms		Cough		Phlegm		Wheezy		Chronic Pulmonary Disease	
		Yes	No	Yes	No	Yes	No	Yes	No
$PM_{2.5}$	< 0.5	2	39	5	36	1	40	4	37
	> 0.5	21	225	44	202	7	239	27	219
Cotton Dust	< 0.5	1	11	2	10	0	12	0	12
	> 0.5	22	253	47	228	8	267	31	244
Smoking	Yes	5	60	19	46	2	64	7	58
	No	18	204	30	192	6	216	24	198

Table 5: Additive effect of smoking with cotton dust and PM $_{2.5.}$

Symptoms				Cough		Phlegm		Wheezy		P-Value			
				Yes	No	Yes	No	Yes	No	MVC	MFVC	$MFEV_1$	$MFEV_1$/ MFVC
$PM_{2.5}$ mg/m^3	< 0.5	Smoking	Yes	1	4	0	5	0	5	0.992	0.708	0.493	0.121
			No	1	35	5	31	1	35				
	> 0.5		Yes	4	56	19	41	2	58	0.035	0.016	0.047	0.113
			No	17	169	25	161	5	181				
Cotton Dust mg/m^3	< 0.5		Yes	0	2	1	1	0	2	0.191	0.233	0.745	0.120
			No	1	9	1	9	0	10				
	> 0.5		Yes	5	58	18	45	2	61	0.039	0.048	0.382	0.047

The workers who smoked with high cotton dust exposure had significant lung function decrement as compared to nonsmoker.

Associations between lungs function and exposures to cotton dust

Dust content differ in different sections of the hosiery plant under the study. There is a lot of variation of total dust among different sections of the enterprise while difference among $PM_{2.5}$ concentrations is comparatively little. However, the frequencies of impaired lungs function in smoking workers were higher than those in nonsmoking workers as shown in Table-5. Significant difference in the proportion of impaired lungs function was found between smokers and nonsmokers in this study. The lungs function was taken in mL while total dust and $PM_{2.5}$ in mg/m^3. There were ten outliers in the analysis near middle of the dataset line. Two outliers were very far from the line with large positive residuals. However, the leverage of the outliers was minimum and slope estimations were unaffected by omitting them. Rest of the outliers were simple and ineffective.

DISCUSSION

In this study respiratory health and lungs function of textile processing workforce relative to exposure to organic dust were investigated. The total number of subjects understudy was 287 inclusive of sixty-five smokers and 222 nonsmokers. The personal characteristics and respiratory symptoms among the operatives were shown in the Table-1. The respiratory symptoms among them were very low. Derso, Y., et. al., 2021 in their study reported cotton dust as one of the risk factors for the occupational respiratory diseases. In their case control study conducted in northwest Ethiopia concluded that the lung functions of the workers working in cotton ginning factories had reduced (Derso et al. 2021). In a cross sectional study which was carried out in Vietnam to determine the prevalence of the respiratory problems amongst textile workers, a high degree of Asthma related allergies was reported (Ha et al. 2021).

Dangi, B. M., & Bhise, A. R. (Dangi and Bhise, 2017) in their study found that the cotton mills' workers' lungs' capacities are reduced significantly and prone to the respiratory difficulties. Similar study carried out in Bangkok, Thailand amongst home based garment workers reported impairment in the workers' lungs and high degree of respiratory disorders amongst them (Silpasuwan et al. 2016). In a cohort study in China which investigated exposure of the cotton dust and endotoxin and its association with the cancer and reported that the exposure of the cotton dust and endotoxin may be associated with that of cancer mortality (Fang et al 2013). A study conducted in Nepal, reported that the Nepalese textile workers suffers from respiratory difficulties such as coughing, persistent phlegm, and chest tightness (Paudyal et al. 2015).

In the unit under study, raw cotton yarn was knitted and converted into the raw finished goods which were dyed and processed into the final product in accordance with international buyer's demand. Cotton dust and particulates were the only main hazard under study despite some fumes originating in the processing section of this textile plant. The total cotton dust level and $PM_{2.5}$ in different sections of the factory are given in Table-2 which ranged from 0.13 mg/m^3 in the boiler section to 0.91 mg/m^3 in knitting section while $PM_{2.5}$ values ranged from 0.32 mg/m^3 to 1.02 mg/m^3 in Administration/EHS and yarn dyeing section of the facility respectively.

But critically if we have a glance, there is a lot of variation of total dust among different sections of the enterprise while difference among $PM_{2.5}$ concentration is little. All equipment and machinery of the facility were newly installed and health and safety measures were taken, to some extent, to reduce air borne exposure of different hazards at workplace specifically cotton dust. It was noted that workers in this factory were provided with improper dust masks to wear during the working hours and most of them were not using them. Also, the floors of different sections of the factory were cleaned with wet mopping on regular intervals during the working shift to reduce air borne cotton dust. Further proper local exhaust ventilation system at full swing was also noted by the researchers. As there is no such study which describe the concentration of cotton dust in hosiery facility has passed through the eyes of authors, for the sack of literature, the work of other researchers in textile sector is quoted for information.

Respiratory illnesses are not included in the priority areas in the Pakistani health system except Tuberculosis and chest infections; this results in often under diagnoses and inappropriate treatment of diseases like asthma, respiratory allergies, and chronic obstructive lung diseases leading to underestimation of the information about respiratory burden and cotton hazards. Two indices of exposure of organic dust were considered during the study: total dust and $PM_{2.5}$ based on weight. Textile industries have been found to be associated with the workplace exposures to chronic lung diseases. More than 60 million textile industries workers worldwide are exposed to this risk. This study reports that the textile dust related lung diseases exhibits the characteristics of asthma and COPD. This study further reports that the evidence suggest that the lung functions improves once exposure to cotton dust gets eliminated (Peggy et al. 2013). There is strong evidence that cotton dust has acute and chronic health effects, such as decreased lungs function and increased bronchial reactivity at levels encountered in this study as shown in Table-3. It is likely that the bulk of these concentrations was due to cotton dust, but we did not analyze the dust samples to show this (one of the limitations).

The dust levels which are there in this industry are reported to be closely associated with lowered lungs function (Smid et al. 1992). This is in agreement with the studies carried out by (Farooque et al. 2018),(Ozkurt et al. 2012). Dust exposure was low in some departments of the plant studied and higher in some other as cited above. Further, Bergstra, A. D., Brunekreef, B., & Burdorf A, in their cross sectional study investigated the impact of heavy industries among the school going children living in the vicinity of the industries and concluded that $PM_{2.5}$ and NOX were associated with the decreased lung functions and dry coughing among children (Bergstra et al. 2018).Moreover, there are several other studies involving workers who are exposed to dust, reveals that dust exposure was less clearly associated with chronic respiratory symptom and lungs function. It was also noted by the authors, major chunk of the work was done during day shifts and less work in the evening and night shifts and comparatively less exposure to organic dust in the later working shifts. The shift work is rotatory in nature. There was significant difference in the total dust and $PM_{2.5}$ concentration measured among four working shifts. Also it was noted that cotton dust level and $PM_{2.5}$ level during the evening and night shifts was low in concentration in comparison with that measured in morning or general shift. Little is known about chronic effects due to occupational exposures in hosiery units. It can be speculated that shift work and low concentration of cotton dust at workplace counters irreversible effects of exposure to organic dust.

When considering duration of employment as a crude cumulative exposure index, an effect seemed to be present because workers who had been employed for more than 5 years had more respiratory symptoms, a relatively decline in lungs function, and more atopy. Zuskin and his associates (Zuskin et al. 1997) expressed that worker exposed to cotton dust were complaining more than the nonsmoker controls about the respiratory illnesses which were enhanced by smoking and adding to morbidity, proved the additive effects of smoking on the health of textiles workers. In a cohort study conducted amongst the male weavers in an Indian city of Varanasi famous for its spinning outlets to find interactive impact of cotton dust and smoking. In this prospective cohort study, subjects were monitored and the results revealed that the lungs capacities were low of the cotton spinning workers and were further impaired to those cotton spinning workers who smoked (Pandey et al. 2017). Our study showed a significant correlation which existed for exacerbation between smoking and cough, phlegm and wheezing among them. In a case control study amongst the women textile workers in Faisalabad and Lahore districts in Pakistan found that working long hours and overtime in textile mills is associated with self-reported symptoms of byssinosis (Khan et al. 2020).

Another problem in our study in the textile processing industry is its cross-sectional nature which does not allow the authors to carry out a proper investigation into drop out of workers. Further, to follow up the subjects under study is near to impossible to verify or resampling the data. An important issue is the symptomatic workers drop out of this industry after a few years of experience. This pattern is also found in other industries, mostly in agricultural sector such as sugar beet refinement (Zock et al. 1998) and railways (Singh and Kawatra, 2014).There is need to consider exposure to response relationship for several years to show healthy worker effect in this sector, if any. However, we could not find any healthy worker effect in this study which is reported mostly in some cross-sectional and longitudinal studies. Another limitation to our study was that we could not manage to measure airborne endotoxin concentrations, endotoxin assays were not performed on the cotton dust sample filters using the Limulus amoebocyte lysate assay due to logistic and financial constraints. Many studies have proved the deleterious effects of endotoxin. Recently, it is demonstrated by some authors that endotoxin may protect the subjects exposed to the organic dust from atopic asthma and other respiratory ailments(Liebers et al. 2008, Azadeh et al. 2018).

CONCLUSION

The prevalence of chronic respiratory ailment was found in this study in comparison with other studies reported in other countries. There are some findings in the study which show an exacerbating association of smoking with cotton dust and $PM_{2.5}$ resulting into decline in lungs function indices and other respiratory impairment. Further, latest advances in technology and awareness about occupational health hazards among workers and safety culture in textile sector has resulted in reduction of cotton dust exposure levels and respiratory symptoms.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

TSP and AM designed and performed experiments and wrote the manuscript. Data and analysis were also conducted by them. All authors including SM, MMG, AMS and MMK reviewed the manuscript and incorporated their inputs at different stages. All authors read and approved the final version.

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