ORIGINAL ARTICLE

EFFECT OF COTTON DUST EXPOSURE ON RESPIRATORY HEALTH OUTCOMES AMONG TEXTILE WORKERS

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Background: Cotton dust is generated during various textile manufacturing processes. Only a few studies from Pakistan assessed cotton dust exposure and explored the relationship of duration of work in the textile industry with respiratory health outcomes. We aimed to assess cotton dust exposure and its association with lung function and respiratory symptoms among textile workers in Pakistan. **Methods:** We report findings from the baseline survey of the larger study, MultiTex, among 498 adult male textile workers from six mills conducted between October 2015-March 2016 in Karachi, Pakistan. Data collection included the use of standardized questionnaires; spirometry, and area dust measurements through UCB-PATS. Multivariable logistic and linear regression models were developed to assess the association of risk factors with respiratory symptoms and illnesses. **Results:** We found the mean age of workers to be 32.5 (±10) years; around 25% were illiterate. The prevalence of COPD, asthma, and byssinosis was 10%, 17%, and 2%, respectively. The median cotton dust exposure was 0.33 mg/m^3 (IQR: 0.12–0.76). Increased duration of work among non-smokers was associated with a decline in lung function, FVC (-245 ml; 95% CI: -385.71, -104.89) and FEV_1 (-200 ml; 95% CI: -328.71, -841.1). Workers with certain job titles (machine operators, helpers, and jobbers), those with greater duration of work, and higher dust exposure, were more likely to report respiratory symptoms and illnesses. **Conclusion:** We report a high prevalence of asthma and COPD and a low prevalence of byssinosis. Cotton dust exposure and duration of employment were associated with respiratory health outcomes. Our findings highlight the need for preventive interventions in the textile industry in Pakistan.

Keywords: Textile Industries; Byssinosis; Lung Function Tests; Cotton Fiber; Occupational Exposure; Pakistan

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INTRODUCTION

Cotton dust is generated during various textile manufacturing processes[1], and is generally categorized into inhalable, thoracic, and respirable fractions, with approximate particle sizes of 100µ, 15µ, and <4µ, respectively[2]. The 'respirable' particles are able to penetrate the gas-exchange region of lungs.[2] Particles with aerodynamic diameters between ≤2.5 µ and ≥0.1 µ are thought to be the most harmful ones[3]; these may cause bronchospasm, and various respiratory symptoms[2]. The National Institute for Occupational Safety and Health (NIOSH) cut-off is 200 µg /m^3 for cotton dust, averaged over eight hours, in most operations except for weaving and spinning, where the limit is 750 µg /m^3, and 500 µg /m^3, respectively.[3] Prolonged exposure to cotton dust may lead to byssinosis, various respiratory symptoms and loss in lung function.[4] Various factors found to be associated with such respiratory conditions include lower educational level, increased duration of work, smoking, and work in dusty areas of mill.[5,6]

In Asia, Pakistan is the eighth largest exporter of textile goods and ranked fourth in terms of production capacity, contributing 60% to the country's total export.[7] Approximately 38% of the Pakistani workforce, around 15 million people, are employed in the textile sector.[8] Despite the gradual decline in the prevalence of byssinosis in developed countries, the situation in developing countries, including Pakistan, is still not satisfactory.[12] Recent estimates show the prevalence of byssinosis and chest tightness among Pakistani textile workers to be between 11–15%.[9,10] Only a few studies from Pakistan assessed cotton dust exposure and its relationship with respiratory health outcomes. Therefore, we conducted this analysis to assess cotton dust exposure and its association with lung function and respiratory symptoms among textile workers in Pakistan.

MATERIAL AND METHODS

We present findings from the baseline survey of the MultiTex pilot study, conducted between October 2015–March 2016 among 498 male textile workers from six purposively selected cotton mills in Karachi, Pakistan.[11] The current analysis focuses on the prevalence of respiratory symptoms, byssinosis, and association of cotton dust exposure with respiratory outcomes. Among the six mills that were included, three (mills 1, 4 and 6) were 'large' (2500–5000 employees), and three 'small' (2, 3 and 5) (500–1000 employees); while two (3 and 5) consisted of weaving section only, and others additionally included spinning (composite mills).

Male textile workers aged ≥18 years from spinning and weaving sections were included while those from wet-processing areas, stitching and packaging sections as well as the administrative staff were excluded. Job titles included (a) 'helper': involved in cleaning, sweeping, and helping the machine operator in different tasks; (b) 'machine operator': responsible for running the machines, and minor maintenance, and trouble-shooting-related work; (c) 'jobber' (or foreman): responsible for trouble-shooting and periodic maintenance of machinery, and incidental repair of machinery in case of malfunctioning; and (d) 'supervisors': responsible for various supervisory and administrative tasks.

We used a modified version of the locally validated American Thoracic Society Division of Lung Disease questionnaire (ATS-DLD-78A)[12,13] that included sections on respiratory symptoms, past medical history, and work exposures. Chronic cough and phlegm were considered when participants reported these symptoms for at least three consecutive months a year, for at least two years. Chronic bronchitis was defined as episodes of cough and phlegm for at least three weeks or more, for at least two years. Those reporting wheeze for at least two years were categorized as having 'chronic wheeze'. Shortness of breath (SOB) grade I was defined as difficulty in breathing when hurrying on the level or walking up a slight hill; grade II was defined as walking slower than persons of the same age, at an ordinary pace on level ground, because of breathlessness. 'Ever smoked any form of tobacco' included *beeri, chillum, huqa*, shisha use ever in a lifetime; or more than one cigarette a day, for one year or more. Questions regarding chest tightness were added from the WHO respiratory questionnaire[14] and byssinosis was classified using Schilling's criteria[15].

We used the Vitalograph In2itive (Vitalograph, UK) spirometer to record the three best pre-and post-bronchodilator values for forced expiratory volume in the first second (FEV_1) and forced vital capacity (FVC), and FEV_1/FVC ratio. Spirometry was conducted by trained technicians on eligible workers. Height and weight measurements were recorded.

We used UCB Particle and Temperature Sensor (UCB-PATS, Berkeley Air) for measuring area-level dust exposure ($PM_{2.5}$ mg/m^3). This is a simple, optical particle counter that carries a photoelectric detector and has previously been used in other studies.[16] The dust monitoring was done by trained technicians during working days in all sub-sections of spinning and weaving at each mill – 5–10 readings were taken from each mill for up to six hours for an 8–12-hour shift. The 8-hour time-weighted averages (TWA) for particulate matter ($PM_{2.5}$) were calculated.

We used Epidata version 3.1 and SPSS V.19.0 (SPSS Inc, Chicago, Illinois, USA) for data entry and analysis, respectively. Frequencies were calculated for categorical variables including the prevalence of respiratory symptoms and illnesses, while median and interquartile range (IQR) for variables with skewed distribution (duration of work at textile mill and cotton dust exposure). We did not find high multicollinearity between any of the independent variables. We found interaction for smoking with cotton dust exposure (*p*-value <0.05) therefore, we conducted stratified analysis for smokers and non-smokers.

We categorized asthma as an increment in FEV_1 of >200 ml or >12% of the baseline value, after administering bronchodilator[17] and COPD as the presence of post-bronchodilator FEV_1/FVC ratio <0.7[18]. Asian cut-offs for BMI were used: <18.5 for underweight, 18.5–22.9 for normal-weight, and 23–24.9 and above, for overweight.[19] Out of a total of 498 workers recruited, acceptable spirometry was available for 410 (82.3%) of workers for analysis - 60 (12.0%) workers refused to perform and 28 (5.6%) were not able to provide spirometry of acceptable quality. We developed multivariable linear regression (FEV_1, FVC, and FEV_1/FVC) and logistic regression models (respiratory symptoms and illnesses).

Approval for the study was taken from the ethics review committee at Aga Khan University, Karachi (2423-CHS-ERC-12). Workers with abnormal spirometry were counselled and referred for further assessment and management

RESULTS

We found the mean age of study participants to be 32.5 (±10) years while up to a quarter of the participants were illiterate (n=126). We found that 29% (n=144) of workers were underweight and 26% (n=128) were smokers. The majority worked as machine operators (n=242; 49%) and were from the weaving section (n=392; 79%). The median cotton dust exposure was 0.33 mg/m^3 (IQR: 0.12-0.76) (Table-1). We found 29% (n=145) had SOB grade II; 12% (n=60) had chest

tightness; 5% (n=26) had chronic bronchitis, i.e., 10% had COPD; 17% had asthma; and 2% had byssinosis.

For univariate linear regression analysis, we found that increased cotton dust exposure resulted in a decline of around 0.04 (95 % CI: -0.07, -0.005) in FEV_1/FVC among smokers. Whereas for non-smokers, increased duration of work, resulted in a decline of 345 ml (95% CI: -493.75, -196.0) in FVC, 368 ml (95% CI: -500.79, -234.25) in FEV_1, and 0.03 (95% CI: -0.04, -0.01) in FEV_1/FVC. After adjusting for covariates, among non-smoker, jobbers showed a decline of 244 ml (95% CI: -488.12, -0.65) for FVC, 236 ml (95% CI: -447.01, -231.81) for FEV_1 and 0.01 (95% CI: - 0.02, 0.4) for FEV_1/FVC ratio. Similarly, significant decline was observed for non-smokers in FVC (-245.30 ml; 95% CI: -385.71, -104.89) and FEV_1 (-200 ml; 95% CI: -328.71, -841.1) with increased duration of work. Whereas for smokers there was a significant decline in FEV_1/FVC, i.e., -0.04 (95% CI; -0.06, -0.10) with increased cotton dust exposure. In univariate logistic regression analysis, workers who had increased age, BMI of <18.5, were illiterate, and working as jobber and helper, were more likely to report respiratory symptoms. After adjusting for covariates, we found that underweight workers (BMI <18.5) were more likely to report ever cough (AOR: 2.19; 95% CI: 1.14, 4.25), asthma (AOR: 2.30; 95% CI: 1.17, 4.85), SOB grade I (AOR: 2.18; 95% CI: 1.15, 5.58), and SOB grade II (AOR: 5.59; 95% CI 1.73, 8.12) (Table 4). Helpers were more likely to report COPD (AOR: 2.98; 95% CI: 1.29, 6.87), machine operators were more likely to report ever cough (AOR: 2.54; 95% CI: 1.15, 5.64), whereas jobbers were more likely to have asthma (AOR: 3.08; 95% CI: 1.22, 7.45). Exposure to environmental tobacco smoke was significantly associated with SOB grade II (AOR: 2.42; 95% CI: 1.02, 5.73). Duration of work in textile mill was significantly associated with ever cough (AOR: 1.06; 95% CI: 1.03, 1.19) and chronic phlegm (AOR: 1.11; 95% CI: 1.03, 1.16). Workers with higher cotton dust exposure were more likely to report chronic wheeze (AOR: 1.67; 95% CI: 1.09, 2.89).

Table-1: Socio-demographic and occupation-related characteristics of study participants (n=498)

Characteristics	Total	Mill 1	Mill 2	Mill 3	Mill 4	Mill 5	Mill 6
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Age (in years) (mean, SD)	32.48 (±10.34)	18(±11.41)	29.15(±11.13)	33(±8)	31(±11)	32(±9)	32(±8)
Educational status							
Illiterate	126 (25.3)	29 (24.4)	11 (32.4)	4 (19)	49 (31.6)	15 (15.5)	18 (24.7)
Primary or middle	202 (40.6)	55 (46.2)	17 (50)	8 (38.1)	62 (40)	35 (36.1)	25 (34.2)
Matric and above	170 (34.1)	35 (29.4)	6 (17.6)	9 (42.9)	44 (28.4)	47 (48.5)	30 (41.1)
BMI (kg/m^2)							
Normal	200 (40.2)	55 (46.2)	13 (38.2)	9 (42.9)	46 (29.7)	44 (45.4)	33 (45.2)
Underweight	144 (28.9)	23 (19.3)	16 (47.1)	5 (23.8)	72 (46.5)	11 (11.3)	17 (23.3)
Overweight & above	154 (30.9)	41 (34.5)	5 (14.7)	7 (33.3)	37 (23.9)	42 (43.3)	23 (31.5)
Job designation							
Helper	124 (24.9)	28 (23.5)	5 (14.7)	14 (66.7)	31 (20)	27 (27.8)	20 (27.4)
Machine operator	242 (48.6)	66 (55.5)	23 (67.6)	7 (33.3)	88 (56.8)	33 (34)	25 (34.2)
Jobber	58 (11.6)	17 (14.3)	2 (5.9)	0 (0)	21 (13.5)	5 (5.2)	13 (17.8)
Supervisor	74 (14.9)	8 (6.7)	4 (11.8)	0 (0)	15 (9.7)	32 (33)	15 (20.5)
Section of mill							
Weaving	392 (78.7)	94 (79)	26 (76.5)	18 (85.7)	127 (81.9)	69 (71.1)	58 (79.5)
Spinning	106 (21.3)	25 (21)	8 (23.5)	3 (14.3)	28 (18.1)	28 (28.9)	15 (20.5)
Exposure to environmental tobacco smoke[a]							
No/one risk factor	283 (56.8)	78 (65.5)	11 (32.4)	14 (66.7)	90 (58.1)	65 (67)	25 (34.2)
More than one risk factor	215 (43.2)	41 (34.5)	23 (67.6)	7 (33.3)	65 (41.9)	32 (33)	48 (65.8)
Ever smoked any form of tobacco[b]							
No	370 (74.3)	96 (80.7)	21 (61.8)	16 (76.2)	113 (72.9)	71 (73.2)	54 (74)
Yes	128 (25.7)	23 (19.3)	13 (38.2)	5 (23.8)	42 (27.1)	26 (26.8)	19 (26)
Daily working hours							
≤8	279 (56)	102 (85.7)	1 (2.9)	3 (14.3)	149 (96.1)	21 (21.6)	4 (5.5)
>8	219 (44)	17 (14.3)	33 (97.1)	18 (85.7)	6 (3.9)	76 (78.4)	69 (94.5)
Duration of work in the textile industry (in years) (median, IQR)[c]	5 (2-8)	5 (3-10)	5 (2-8)	5 (3-10)	5 (3-8)	3 (2-8)	4 (2-6)
Cotton dust exposure (mg/m^3) (median, IQR)[d]	0.33 (0.12–0.76)	1.64 (0.05–1.67)	0.09 (0.02–0.14)	---	0.44 (0.42–0.53)	0.39 (0.12–0.74)	0.22 (0.09–0.26)

[a] Exposure to environmental tobacco smoke refers to second-hand smoke, or exposure to passive smoking at home, or place of work. Workers not exposed or exposed to any one place (home, or place of work) were categorized as having 'no, or one risk factor' while those with multiple exposures were categorized as 'more than one risk factor'

[b] Ever smoked any form of tobacco includes smoked tobacco (cigarettes, *beeri*, *huqqa*, *chilum*, *shisha*)

[c] Average number of years during which the worker has remained in the textile industry

[d] Current section-level average exposure of the workers to the cotton dust in the textile mill, measured by UCB PATS device

Table-2: Multivariable linear regression models for lung function outcomes stratified according to smoking status (n=410)

	FVC[a] (ml)	FVC (ml)	FEV_1[b] (ml)	FEV_1 (ml)	FEV_1/FVC	
	Smokers	Non-smokers	Smokers	Non-smokers	Smokers	Non-smokers
Characteristics	Beta (95% CI)	ml (95% CI)	Beta (95%CI)	Beta (95% CI)	Beta (95% CI)	Beta (95% CI)
Age (years)	-15.87 (-27.24, -4.50)	-12.88 (-19.44, -6.44)	-28.42 (-38.47, -18.366)	-20.34 (-26.05, -14.63)	-0.04 (-0.05, -0.02)	-0.03 (-0.003, -0.03)
Height (cm)	43.86 (27.72, 53.99)	45.10 (35.67, 54.53)	33.38 (19.11, 47.64)	35.64 (27.43, 43.86)	-0.004 (-0.002, 0.001)	-0.0005 (-0.002, 0.001)
Job designation						
Supervisor (ref)						
Helper	-350.6 (-331.65, 401.78)	-147.48 (-349.84, 54.87)	-104.80(-429.02, 219.40)	-843.2 (-260.58, 91.92	-0.03 (-0.07, 0.019)	-0.01 (-0.02, 0.04)
Machine operator	-146.23 (-169.69, 462.16)	-142.9 (-191.42, 162.84)	154.32(-124.98,433.63)	-167.5 (-137.5, 171.0)	0.03 (-0.01, 0.08)	-0.01(-0.2, 0.04)
Jobber	-291.99 (-106.31, 690.29)	-244.39 (-488.12, -0.65)	280.80(-71.32, 632.92)	-235.40 (-447.01, -23 1.81)	0.38 (-0.01, 0.09)	-0.01(- 0.02, 0.4)
Duration of work in textile mills [b](years)						
1-5 (ref)						
≥ 6	154.6 (-201.29, 232.22)	-245.3 (-385.71, -104.89)	-505.0 (-196.64, 186.58)	-206.41(-328.71, -841.1)	-0.01(-0.03, 0.02)	-0.01(-0.02, 0.10)
Cotton dust exposure in textile mills (mg/m^3) [d]						
Low (0.04-0.32) (ref)						
High (≥ 0.33)	-711.1 (-289.87, 143.644)	504.3 (-788.7, 179.74)	-146.70 (-336.54, 43.16)	674.0 (-452.20, 180.03)	-0.04 (-0.06, -0.10)	-0.004 (-0.02, 0.1)
Environmental tobacco smoke						
No /one risk factor (ref)						
More than one risk factors	-403.3 (-258.69, 232.22)	-565.1 (-184.59,71.56)	596.0 (-187.08, 199.01)	-640.40 (-175.6, 47.51)	0.0008 (-0.026, 0.028)	-0.005 (-0.02, 0.10)
aR^2	0.23	0.32	0.31	0.37	0.36	0.17

[a] Forced Vital Capacity. [b] Forced Expiratory Volume in the first second. [c] Number of years during which the worker has remained in textile industry categorize into quartiles and merging around the median to make a binary variable. [d] Current average exposure of the workers to the cotton dust in the textile mill, measured by UCB PATS device, categorized into quartiles and merged using median as a cut-off to make a binary variable

Table-3: Multivariable logistic regression analysis for respiratory symptoms and illnesses (n=498)

	Ever cough	Chronic cough	Ever wheeze	Chronic wheeze	Ever phlegm	Chronic phlegm	SOB grade I[a]	SOB Grade II	COPD	Asthma
Variables	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Age in years	0.98 (0.95, 1.01)	0.95 (0.91, 0.99)	1.00 (0.97, 1.03)	1.02 (0.97, 1.04)	0.96 (0.93, 0.99)	0.94 (0.91, 0.97)	1.00 (0.96,1.04)	0.99 (0.96, 1.04)	0.92 (0.88, 0.94)	0.99 (0.96, 1.02)
Educational status										
Matric and above	-	-	-	-	-	-	-	-	-	-
illiterate	1.59 (0.81, 3.12)	2.92 (1.03, 8.28)	1.38 (0.74, 2.61)	1.42 (0.66, 3.13)	1.11 (0.60, 2.04)	0.95 (0.45, 1.99)	-	-	1.32 (0.11, 2.85)	3.07 (1.43, 6.59)
Primary/middle	1.41 (0.78, 2.53)	2.03 (0.79, 5.17)	1.17 (0.66, 2.07)	1.49 (0.75, 2.98)	0.69 (0.48, 1.19)	0.71 (0.37, 1.31)	-	-	0.64 (0.25, 1.61)	2.38 (1.22, 4.64)
BMI										
Overweight 23-24.9 and above	-	-	-	-	-	-	-	-	-	-
Normal	1.69 (0.91, 3.12)	1.13 (0.45, 2.87)	0.89 (.517, 1.54)	1.05 (0.54, 2.05)	1.44 (0.83, 2.50)	1.09 (0.58, 2.03)	0.71 (0.33, 1.54)	1.39 (0.65, 2.99)	0.52 (0.24, 1.15)	1.37 (0.77, 2.44)
Underweight <18.5	2.19 (1.14, 4.25)	1.74 (0.66, 4.53)	0.96 (0.52, 1.76)	1.28 (0.62, 2.66)	1.13 (0.60, 2.13)	0.64 (0.30, 1.37)	2.18 (1.15, 5.58)	5.59 (1.73, 8.12)	0.81 (0.29, 2.25)	2.30 (1.17, 4.85)
Job Designation n, (%)										
Supervisor -		-	-	-	-	-	-	-	-	-
Helper	1.08 (0.59, 1.97)	1.40 (0.53, 3.69)	1.08 (0.44, 2.61)	1.24 (0.42, 3.65)	1.46 (0.65, 3.28)	1.22 (0.47, 3.15)	1.34 (0.54, 3.29)	0.75 (0.30, 1.83)	2.98 (1.29, 6.87)	1.77 (0.91,3.44)
Machine operator	2.54 (1.15, 5.64)	2.82 (0.81, 9.83)	1.97 (0.88, 4.39)	1.69 (0.63, 4.55)	1.31 (0.62, 2.80)	1.26 (0.53, 3.00)	1.58 (0.47, 5.34)	0.63 (0.19, 2.14)	1.65 (0.47, 5.75)	1.25 (0.41, 3.61)
Jobber	0.95 (0.39,2.36)	2.27 (0.59, 8.73)	1.17 (0.44, 3.09)	1.55 (0.49, 4.89)	2.05 (0.86, 4.85)	2.02 (0.76, 5.32)	1.90 (0.66, 5.45)	0.52 (0.18, 1.49)	0.95 (0.32, 2.80)	3.08 (1.22, 7.45)
Section of the mill n, (%)										
weaving	-	-	-	-	-	-				
spinning	0.68 (0.37, 1.28)	-	0.88 (0.49, 1.60)	1.48 (0.76, 2.88)	0.96 (0.56, 1.66)	1.02 (0.53, 1.92)		-	-	-
Exposure to environmental tobacco smoke										
No or one risk factor/ exposure			-	-	-	-	-	-	-	=
More than one risk factor	1.1 (0.68, 1.76)	1.02 (0.51, 2.03)	1.07 (0.68, 1.68)	1.24 (0.73, 2.12)	1.35 (0.87, 2.10)	1.35 (0.80, 2.28)	1.41 (0.17, 0.98)	2.42 (1.02, 5.73)	-	-
Ever smoked any form of tobacco										
No	-	-	-	-	-	-	-	-	-	-
Yes	1.22 (0.73, 2.06)	1.15 (0.54, 2.45)	1.47 (0.91, 2.40)	1.44 (0.81, 2.56)	-	-	1.49 (0.71, 3.18)	0.67 (0.32, 1.40)	-	-
Duration of work in textile mills [b](years) 1-5 (ref) >6	1.06 (1.00, 1.19)	1.06 (0.98, 1.15)	0.99 (0.94, 1.05)	1.01 (0.95, 1.07)	1.04 (0.99, 1.10)	1.11 (1.03, 1.16)	0.93 (0.85,1.01)	1.07 (0.99, 1.18	1.03 (0.96, 1.10)	0.94 (0.87, 0.99)
Cotton dust exposure in textile mills (mg/m^3)[c] Low (0.04-0.32) (ref) High (≥ 0.33)	0.87 (0.52, 1.45)	1.49 (0.75, 2.98)	1.46 (0.92, 2.30)	1.67 (1.09, 2.89)	0.67 (0.41, 1.10)	0.81 (0.15, 1.44)	0.62 (0.29, 1.35)	1.60 (0.74,3.47)	0.60 (0.3, 1.23)	0.85 (0.49, 1.43)

For each health outcome (respiratory symptoms and illness) the multivariate model includes all the variables listed in the table.

[a] Shortness of breath

[b] Number of years during which the worker has remained in textile industry

[c] Current average exposure of the workers to the cotton dust in the textile mill, measured by UCB PATS device

DISCUSSION

We report a high prevalence of COPD (10%) and asthma (17%), and a low prevalence of byssinosis (2%) among this group of Pakistani textile workers. A significant decline in lung function was observed for machine operators, helpers, and those with an increased duration of work among non-smokers. For smokers, a significant decline in lung function (FEV_1/FVC ratio) was observed with increasing cotton dust exposure. Increased age group, designation as a jobber, helpers, machine operators, being illiterate, having BMI of <18.5 and higher dust exposure were the factors found to be associated with one or more respiratory symptoms and illnesses. We found a higher prevalence of asthma (17%) compared to another study among textile workers (5%)[20], and the general population of Karachi (11%)[21], but lower than among Sri Lankan garment workers (32% for symptoms-based asthma)[22]. Other than a different definition used in the Sri Lankan study, these differences could also be due to some specific workplace factors like use of different dyes & chemicals at the selected mills – therefore, results need to be interpretated with caution.

We found association of different respiratory symptoms with job titles of helper, machine operator, and jobber, and exposure to cotton dust; similar to the findings reported by previous studies from Pakistan and India[5,23], and reflecting a prolonged and higher exposure to cotton dust. In Ethiopia, workers exposed to cotton dust reported more respiratory symptoms (aOR: 8) compared to the non-exposed[24], while other studies also reported respiratory health effects of prolonged cotton dust exposure[6]. Similar to our finding of an association between respiratory symptoms and duration of work, another study found that Ethiopian textile workers with greater than five years of work had 2.38 times higher odds of developing respiratory symptoms[24], finding similar to Egyptian study on textile workers[16].

We found a low prevalence of byssinosis in this sample (2%), which is not consistent with previous studies from Pakistan (11–15%).[9,10] This could be due to an effect of selection bias - "healthy workers" effect that resulted in the overrepresentation of newly hired or healthier workers. A lack of clear understanding of the questions on byssinosis by the workers during the interview could be another reason for such a finding. However, we recommend caution while interpreting this finding based on a small number of mills.

We found a significant association of the decrease in FEV_1/FVC ratio with cotton dust exposure. Other studies reported exposure dependent relationship between cotton dust, lung function and reported that increased exposure of cotton dust was significantly associated with a reduction in FVC (OR=2) and FEV_1 (OR=1.83).[25] Another important finding of this study is the association of decreased lung function (i.e., FVC, FEV_1 for non-smokers, and FEV_1/FVC ratio for smokers) with the duration of work. Long-term cotton dust exposure is associated with obstructive lung diseases[6], while more experienced workers are at a greater risk for developing decrements in lung function[6,24]. Another study from Myanmar showed that workers with 6–10 years of service duration were more likely to show a decrease in lung function (OR=2.8).[25]

A few limitations of this study need to be considered. We included only male textile workers therefore any gender-related differences could not be determined. Since it was a cross-sectional study, we could not determine the long-term respiratory effects of cotton dust exposure. We were not able to include workers who left the job due to any work-related illness, while the use of a self-reported questionnaire for respiratory symptoms may have led to a recall bias.

CONCLUSION

We found a high prevalence of COPD (10%) and asthma (17%), and a low prevalence of byssinosis (2%). Increase in age, designation as a jobber, helpers, machine operators, being illiterate, having BMI of <18.5 and higher dust exposure were the factors found to be associated with one or more respiratory health outcomes among textile workers. This study highlighted the significant association of cotton dust exposure, duration of work and a decline in lung function. Thus, reducing exposure to dust through adequate control and preventive measures is needed to reduce respiratory symptoms and illnesses in textile workers in Pakistan and similar developing countries.

Abbreviations: FEV_1: Forced Expiratory Volume in the first second; FVC: Forced Vital Capacity; COPD: Chronic obstructive pulmonary disease; SOB: Shortness of breath; UCB-PATS: University of California, Berkeley-Particle, and Temperature Monitoring System; PM: particulate matter; NIOSH: The National Institute for Occupational Safety and Health

Ethics approval and consent to participate: Approval for the study was taken from the ethics review committee at Aga Khan University, Karachi (2423-CHS-ERC-12). Written, informed consent was taken from all participants, and confidentiality of data was strictly maintained. The right to ask any questions and to decline participation was given to the participants during the data collection.

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AUTHORS' CONTRIBUTION

AN conceived the study. AS, YA, HNT, NS contributed to the development of the study protocols and fieldwork. AN, AS and YA contributed to data analysis and writing the manuscript and MI supervised the spirometry process. All authors reviewed and approved the final version of the manuscript

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