OEM Online First, published on November 15, 2012 as 10.1136/oemed-2011-100561

ORIGINAL ARTICLE

Pattern and predictors for respiratory illnesses and symptoms and lung function among textile workers in Karachi, Pakistan

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▸ Additional supplementary files are published online only. To view these files please visit the journal online (http://dx.doi.org/10.1136/oemed-2011-100561).

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Accepted 17 October 2012

ABSTRACT

Objectives To determine pattern and predictors for respiratory illnesses and symptoms and lung function among textile workers in Karachi, Pakistan.

Methods This was a cross-sectional survey of 372 adult male textile workers from the spinning and weaving sections of 15 textile mills from Karachi. Data were collected from November to December 2009 through a structured, pretested questionnaire and spirometry.

Results Prevalence of byssinosis was 10.5%, chronic cough 7.5%, chronic phlegm 12.9%, wheeze with shortness of breath 22.3%, shortness of breath (grade 2) 21%, chest tightness ever 33.3%; whereas, a low prevalence of asthma (4%) was identified in this population. Eight per cent had obstructive, 8% restrictive and 2% mixed pattern of lung function abnormality. After controlling for potential confounders, work in the spinning section predicts frequent wheeze (AOR=2.0; 95% CI 1.1 to 3.5), wheeze with shortness of breath (AOR=1.8; 95% CI 1.0 to 3.4), and obstructive pattern on spirometry (AOR=2.5; 95% CI 1.0 to 6.2). Prolonged duration of work predicts breathlessness grade 1 (AOR=1.8; 95% CI 1.0 to 3.1) and grade 2 (AOR=2.7; 95% CI 1.3 to 5.4), as well as decrements in Forced Expiratory Volume in the first second (FEV_1) and FEV_1/Forced Vital Capacity ratio. Lack of education predicts frequent wheeze (AOR=2.0; 95% CI 1.2 to 3.3), and Sindhi ethnicity predicts chest tightness apart from during cold (AOR=2.7; 95% CI 1.1 to 6.6).

Conclusions This study highlights the burden of respiratory illnesses and symptoms, and a low prevalence of asthma among textile workers in Karachi. Work in the spinning section, lack of education, prolonged duration of work and Sindhi ethnicity, were identified as important risk factors.

What this paper adds

- Textile workers are at risk of acquiring a host of respiratory illnesses and symptoms due to exposure to cotton dust, including byssinosis, asthma, chronic cough and others. Therefore, in order to assess the burden of respiratory morbidity associated with textile workers' work environment, it is imperative that a holistic approach should be taken.
- There are only few studies available worldwide, and the information is especially scarce in Pakistan. Furthermore, apart from sampling methodology limitations (a small and non-representative sample), most of the previous studies lack objective assessment of lung function, as they have not used spirometry.
- This study found the most commonly reported respiratory symptoms and illnesses to be shortness of breath grade 1 (46.8%), frequent wheeze (39.8%) and byssinosis (10.5%), whereas a low prevalence of asthma (4%) was identified.
- Lung function assessment through spirometry found that 8% of participants had an obstructive pattern, 8% restrictive and 2% had mixed pattern on spirometry.
- This study identifies the spinning section, lack of education, prolonged duration of work and Sindhi ethnicity as important factors which may be prioritised for preventive measures targeting textile workers.

INTRODUCTION

Exposure to cotton dust is associated with various systemic and pulmonary health effects. Systemic effects range from generalised malaise to rise in body temperature,[1] while pulmonary effects include cough, phlegm, chronic bronchitis, asthma, byssinosis and emphysema.[2 3] Pulmonary effects have also been objectively reported by a few studies, through spirometry, as decrement in lung function.[4 5]

Schilling, in 1963, described criteria for grading of byssinosis based on symptoms of chest tightness which have been extensively used in epidemiological studies since then.[6] Another grading system based on lung function changes that occur due to exposure to cotton dust has also been used. This system categorises lung function changes as acute or chronic, based on changes in Forced Expiratory Volume in 1 s (FEV_1). An acute effect is graded according to the degree of lung function loss during work exposure, and a chronic effect according to the degree of permanent loss, as a percentage of the predictive value.[7]

Work in the textile industry can be broadly divided into four processes[8]: yarn formation (spinning), fabric formation (weaving), wet processing and fabrication. Cotton dust is generated in variable concentrations throughout the various processes being undertaken in the textile industry. The initial processing of cotton, involving raw cotton, leads to highest dust exposure to textile workers. Therefore, the spinning section (involving subcomponents, such as bale opening, blowing, carding and spinning) has higher dust exposure compared with weaving and others sections.[1]

Respiratory illnesses and symptoms, including byssinosis, have been reported by workers employed at various processes in the textile industry from across the globe.[3 5 9] Over the years, the prevalence of byssinosis has gradually declined in developed countries due to improvements in dust control measures. Studies from UK found 10% prevalence of byssinosis in carding workers, 3% in spinning workers, 3% in winders and 0.3% among weavers.[9 10] However, the situation in developing countries is still worse, where large numbers of textile workers continue to suffer from respiratory illnesses. A study conducted in Ethiopia found prevalence of byssinosis to be as high as 43.2% among blowers and 37.5% among carders, whereas a high percentage of bronchial asthma from 8.5% to 20.5% was reported across all sections.[3] Similarly, a study from China reported 32% byssinosis[5] and a high prevalence of other respiratory illnesses and symptoms, including chronic bronchitis, cough and dyspnoea, among cotton textile workers. Studies conducted in other developing countries found a byssinosis prevalence of 14.2% among cotton-processing workers in a thread-producing mill in Turkey; and 12.6% among spinning and weaving section workers in Taiwan.[11 12] Possible reasons for the difference in prevalence could include methodological limitations, such as inadequate sample size and inappropriate sampling technique, or it could be due to variation in cotton dust exposure and occupational safety status of these countries.

Factors found more likely to be associated with respiratory illnesses and symptoms among textile workers include: bale opening, blowing, carding, spinning sections of the textile mill, smoking, low educational status, non-use of safety gadgets, higher exposure to endotoxins and prolonged duration of work.[13–16] Smoking has an additive effect with cotton dust exposure on respiratory symptoms and pulmonary function of textile workers.[11]

Few studies have assessed respiratory illnesses among textile workers in Pakistan. Studies conducted in the 1990s found the prevalence of byssinosis to be around 8–15%, chronic bronchitis or asthma 3.6% and lung function abnormality 20–38%.[17–19] Two recent studies from Karachi by Farooque *et al* and Memon *et al*, published in 2008, report a higher prevalence of byssinosis compared with earlier studies, that is, 19.28–35.6%. These studies found that factors associated with respiratory illnesses and symptoms include work in spinning, ring and carding areas, low educational status and non-use of face masks.[15 16]

Cotton dust exposure at textile industries adds considerably to the occupational burden of disease globally. In Pakistan, the textile industry employs a large workforce (approximately 38%),[20] and contributes significantly to the national economy. However, there is paucity of data on the respiratory health of these workers. Most of the available studies are questionnaire-based, and have methodological limitations, such as inadequate sample size, thus limiting their representativeness. We endeavoured to carry out an epidemiological study based on objective assessment through spirometry to determine the holistic pattern of respiratory illnesses and symptoms and lung function, and also to identify predictors, so that appropriate preventive measures can be recommended for textile workers in Pakistan.

MATERIALS AND METHODS

Study design and setting

This was a cross-sectional survey conducted from August to December 2009 among male textile workers of Karachi, Pakistan. Karachi, a mega city and the largest urban centre of Pakistan, is estimated to have a population of over 15 million,[21] which comprises a mix of various ethnolinguistic groups found in the country.[21] Being the financial capital of Pakistan and the country's only port, Karachi hosts major industries and businesses, and accounts for the greatest share of the national gross domestic product and revenue. The city has 4500 industrial units in the formal sector, although there are no estimates available for the informal sector, where 75% of the working population is employed.[22]

Sampling strategy

According to recent estimates available from the department of labour, Government of Sindh, (2009), there are 794 registered textile units with approximately 40 500 workers in Karachi, who are primarily involved in the spinning and weaving of cotton and synthetic textiles. There are five main industrial areas in Karachi where textile mills are located, and we included a total of 15 textile mills, selected through convenience sampling, one each from Korangi/Landhi Industrial Area and North Karachi Industrial Area, two from Federal 'B' Area Industrial Area, four each from Sindh Industrial Trading Estate (SITE), and SITE Super Highway. In addition to these main industrial areas in the city, we also included one textile mill each from Ittehad town, Baldia town and SITE Nooriabad, located in the suburbs of Karachi.

This study focused on the spinning and weaving sections, as high dust exposure was expected in these sections. In this study, most of the mills were composite, as they had both these sections. We have categorised the processes of bale opening, blowing, carding, drawing, work at open end, twisting/doubling and cone winding as 'spinning'; workers from the waste plant were also included here. The category 'weaving' includes warping, knotting, work at power looms and folding/mending sections. Workers employed in wet processing, stitching and packaging sections, as well as the managerial and administrative staff, were excluded from the study, as very low cotton dust exposure is expected among these populations.

Selection of study participants

We selected 372 male workers from textile mills of Karachi (due to the overwhelming majority of men in the target population), in sections of weaving and spinning, working for at least 1 year, and aged 18 years or more. A few workers who were unable to understand Urdu language, and for whom no interpreter could be arranged, were excluded. Those who were not able to perform spirometry were also excluded. The total non-response rate was roughly 3.9%. Approximately half the sample was selected from spinning, and the other half from the weaving section. A relatively quiet room/area within the mill was identified for conducting interviews and spirometry. Workers were recruited into the study with the help of an attendance register or attendance log maintained at the mills. All those workers who were present at a particular mill during the visit of the study team, and who met the inclusion criteria were asked to participate, and those who were willing were recruited. Administrative staff were only involved for facilitating the process, while selection was made at the discretion of study team.

Interviews

A modified version of the validated American Thoracic Society Division of Lung Disease questionnaire (ATS-DLD-78A) was used for interviews.[23] It includes questions regarding cough, phlegm, wheezing, shortness of breath, other chest and past illnesses and family history. Questions pertaining to chest tightness were added from the respiratory questionnaire of WHO Technical Report Series 684.[7] The structured questionnaire was translated into Urdu, back-translated into English, and pretested before use in the study. Interviews were conducted by trained data collectors, and the time required for filling in the questionnaire was approximately 20–30 min.

Lung function measurements

Lung function measurements were performed with a portable spirometer (Vitalograph New Alpha 6000; Vitalograph Ltd, Buckingham, England, UK) according to the American Thoracic Society guidelines.[24] Percentage-predicted FEV_1, Forced Vital Capacity (FVC) and their ratio (FEV_1/FVC) were recorded in millilitres, and the predicted percentages were based on standardised equations of the European Respiratory Society 1993, with a correction factor of 0.9 for an Asian population.[25] Participants were asked to refrain from smoking for at least 1 h before spirometry. All spirometry measurements were made in a standing position without nose clips. The procedure was explained to participants and they were asked to practice until they felt comfortable. Results of three acceptable readings were recorded, and the best of the three readings was used for further analysis. All spirometry was conducted on working days (Mondays through Saturdays) and during working hours (includes morning and night shifts), so that each participant had been exposed to cotton dust at the time of test. Lung function measurements were conducted by a trained physician and, for purpose of quality assurance, spirograms were reviewed by a pulmonologist before inclusion in the study.

Anthropometric measurements

Standing height (in cm) was measured for all participants with shoes removed, using a height board, while weight (in kg) was measured while dressed in light clothing and without shoes, using a bathroom scale.

Definitions:

- Chronic cough or phlegm: cough or phlegm for at least three consecutive months a year, for at least 2 years.
- Chronic wheeze: whistling sounds from chest (with or without cold), for at least 2 years.
- Breathlessness (grade 2): walking slower than persons of the same age, at an ordinary pace on level ground, because of breathlessness.
- Asthma: self-reported or physician-diagnosed asthma.
- Byssinosis (according to Schilling's criteria): symptoms of chest tightness with or without shortness of breath within 3–4 h of entering the textile mill on the first day of the work week at least once during the past 6 months.
- Smoking status: ever smoker means more than 20 packs of cigarettes in a lifetime or more than 1 cigarette a day for 1 year. Pack-years of smoking was calculated using the formula: pack-years of smoking=(cigarettes per day×years of smoking)/20.
- Spirometric interpretations (based on percentage-predicted lung volumes as determined through the spirometer): normal ($FEV_1/FVC>0.7$, FEV_1 and FVC>80% predicted); obstructive ($FEV_1/FVC<0.7$, $FEV_1<80\%$ predicted); restrictive ($FEV_1/FVC>0.7$, FEV_1 and FVC<80% predicted); mixed (a combination of obstructive and restrictive patterns).

Ethical approval

The study was approved by the ethics review committee of Aga Khan University, Karachi. Written informed consent was taken from all participants before being enrolled in the study, and confidentiality of data was strictly maintained. The data of the workers were not shared with the employer; however, it was shared with the individual workers on request. Workers with abnormal spirometry were counselled and referred to a tertiary care hospital for further assessment and management.

Statistical methods

Data were entered on Epidata 3.1 and analysed using SPSS V.19.0 (SPSS Inc, Chicago, Illinois, USA). Frequencies were calculated for categorical variables, while mean and SD (or median and IQR) for continuous variables. Prevalence was estimated for presence of respiratory symptoms and illnesses, as well as spirometric interpretation. Multicollinearity was assessed between all independent variables, as well as between the respiratory symptoms, by applying appropriate statistical tests depending on the type of variables (Pearson (Pearson for continuous, Kendall for ordinal and Phi & Cramer for nominal type of variable), Kendall and Phi & Cramer). 'Very strong' correlations (correlation coefficient≥0.8) were not observed between any of the independent variables or respiratory symptoms (see online supplemental table S1).

Univariate ORs and their 95% CIs were calculated to assess associations between respiratory symptoms/illnesses and covariates (including section of mill, pack-years of smoking, duration of work, educational status, marital status, household income per person, mill cluster and ethnicity). All variables with p value of ≤0.25, and those which had a biologically plausible relationship with the outcome variable were included in multivariate models. Multivariate logistic regression models were developed separately for each outcome variable (respiratory symptoms/illnesses). Univariate OR were also calculated for obstructive patterns of spirometry, and significant variables were further assessed in a multivariate model.

Separate analyses were also carried out to determine association between lung function indices, that is, percentage-predicted FEV_1, FVC and FEV_1/FVC ratio; and covariates through multivariate linear regression analysis.

RESULTS

Frequency distributions of sociodemographic, anthropometric, life style and occupational factors of 372 male textile workers who were included in this study are presented in table 1. Overall, 46.8% workers were employed in the spinning section, while 53.2% were employed in the weaving section. According to the smoking status, the majority (57.8%) were non-smokers, whereas 34.6% were current smokers, and 7.5% ex-smokers. Regarding duration of work, 31.7% had been working in textile mills for 1–5 years, 35.5% for 6–10 years and 32.8% for 11 years or more. The majority (73.9%) of workers were educated, and with a median monthly household income per person of rupees 1714.2 (IQR=1157 to 2553), where US$1≈90 Pakistani rupees. The mean age of the participants was 27 years (SD=8.5).

Frequencies of respiratory symptoms and illnesses as reported by the participants are presented in table 2. Shortness of breath grade 1 (46.8%; 95% CI 41.7 to 51.8) and frequent wheeze (39.8%; 95% CI 34.8 to 44.7) were the most commonly reported symptoms. Overall, 82% of the participants had normal spirometry values, 8% obstructive, 8% restrictive and 2% mixed pattern.

Table 1 Frequency distribution of sociodemographic, anthropometric, life style and occupational factors of male textile workers (n=372), Karachi, Pakistan

Variable	Frequency	Percentage
Section of mill		
Spinning	174	46.8
Weaving	198	53.2
Smoking status		
Non-smokers	215	57.8
Ex-smokers	28	7.5
Current smokers	129	34.6
Pack years of smoking		
Non-smokers	215	57.8
Less than 10 years	130	34.9
10 or more years	27	7.3
Duration of work		
1–5 years	118	31.7
6–10 years	132	35.5
11 years or more	122	32.8
Educational status		
No formal education	97	26.1
Primary	90	24.2
Lower secondary	89	23.9
Secondary and above	96	25.8
Marital status		
Ever married	191	51.3
Never married	181	48.7
Ethnicity		
Punjabi	103	27.7
Pushtu	52	14
Sindhi	116	31.2
Urdu	35	9.4
Others*	66	17.7
Mill cluster†		
Cluster 1	129	34.7
Cluster 2	22	5.9
Cluster 3	106	28.5
Cluster 4	73	19.6
Cluster 5	42	11.3
Household income per person‡ §	1714.2	(1157–2553)
Age (years)¶	27.1	(8.49)
Height (cm)¶	167.2	(6.2)
Weight (kg)¶	58.6	(11.4)

*Includes other ethnolinguistic groups: Baluchi, Seraiki, Hindko, Kohistani and Kashmiri.
†Where cluster 1 comprises of: SITE Super Highway and Landhi/Korangi Industrial areas; cluster 2: Baldia town and Ittehad town; cluster 3: SITE; cluster 4: SITE Nooriabad; and cluster 5: North Karachi and FB Area Industrial areas.
‡Calculated by dividing monthly household income in Pakistani rupees (Rs) (US $1=90 Rs) by number of household members.
§Median (IQR).
¶Mean (SD) for continuous variables.
SITE, Sindh Industrial Trading Estate.

According to Schilling's criteria, 39 workers (10.5%; 95% CI 7.3 to 13.5) were categorised as having byssinosis, whereas 15 (4%; 95% CI 2 to 6) reported a history of physician-diagnosed or self-reported asthma. Prevalence of byssinosis was 17.8% (n=174) in spinning and 4% (n=198) in the weaving section. Among byssinotic workers, the majority (59%; n=23) had grade 1/2 byssinosis, while 23% (n=9) had grade 1 and 18% (n=7) had grade 2 byssinosis. None were in grade 3 byssinosis. The distribution of chronic respiratory symptoms and illnesses, according to the particular section of the textile mill shows a higher prevalence of most of these symptoms/illnesses in the spinning section (see online supplemental figure S1). A higher proportion of workers reported respiratory symptoms in mills 1, 4, 12 and 15 (table 2), where approximately 15%, 24%, 33% and 51% of workers reported at least one respiratory symptom, respectively.

Respiratory symptoms were more likely to be present among workers of the spinning section, smokers, with prolonged duration of work, with low educational status, lower household income per person, and increasing age in univariate analyses. Univariate analysis for factors associated with abnormal spirometry found pack-years of smoking ≥10 years, duration of work ≥11 years, age and marital status to be significantly associated with an obstructive pattern of spirometry.

After adjustment for confounding variables, workers in the spinning section of the textile mill, smokers, prolonged duration of work, low educational status and lower household income per person were independently associated with respiratory symptoms (table 3). Those working in the spinning section were more likely to have frequent wheeze (AOR=2.0; 95% CI 1.1 to 3.5) and wheeze with shortness of breath (AOR=1.8; 95% CI 1.0 to 3.4) compared with those working in the weaving section. Smokers with pack-years of smoking ≥10 years were more likely to have frequent phlegm (AOR=3; 95% CI 1.2 to 7.5) and frequent wheeze (AOR=7.5; 95% CI 2.7 to 20.5) compared with non-smokers. Those with duration of work ≥11 years were more likely to have breathlessness grade 1 (AOR=1.8; 95% CI 1.0 to 3.1) and breathlessness grade 2 (AOR=2.7; 95% CI 1.3 to 5.4), compared with those with a duration of work <6 years. Uneducated workers were more likely to have frequent wheeze (AOR=2.0; 95% CI 1.2 to 3.3) compared with the educated. The ethnic Sindhi was more likely to be associated with chest tightness apart from during cold (AOR=2.7; 95% CI 1.1 to 6.6) as compared with the Punjabi.

From multivariate analyses, the spinning section of mills (AOR=2.4; 95% CI 1.0 to 5.5) was significantly associated with an obstructive pattern of spirometry after adjusting for confounders (table 4). Analyses of lung function indices are presented in table 5. In the final model, prolonged duration of work was significantly associated with decrements in FEV_1 and FEV_1/FVC ratio after adjusting for confounders.

DISCUSSION

Textile workers are at a greater risk of acquiring a host of respiratory illnesses and symptoms due to exposure to cotton dust.[3 26] Byssinosis is distinct from occupational asthma,[27] and some of the symptoms, for instance, chronic cough, might not fit into a disease complex; however, they are important causes of morbidity in this group of workers and need to be reported.[28 29] Therefore, in order to assess respiratory morbidity associated with the work environment of textile workers it is imperative that a holistic approach to disease patterns be considered. However, there are only a few such studies worldwide,[3 30] and none was conducted to determine the true burden of respiratory illnesses among textile workers in Pakistan.

The prevalence of 10.5% for byssinosis determined from this study is similar to studies from other developing countries: 14.2% among cotton-processing workers in a thread-producing mill in Turkey, and 12.6% among spinning and weaving section workers in Taiwan.[11 12] We found that the prevalence of byssinosis in the spinning section was 17.8%, compared with only

Occup Environ Med 2012;0:1–9. doi:10.1136/oemed-2011-100561

Table 2 Frequency distribution of respiratory illnesses and symptoms, and lung function among textile workers (n=372), Karachi, Pakistan

	Frequency at each mill																
Mill code (n)	**1 (39)**	**2 (18)**	**3 (36)**	**4 (33)**	**5 (13)**	**6 (21)**	**7 (11)**	**8 (11)**	**9 (11)**	**10 (24)**	**11 (8)**	**12 (51)**	**13 (11)**	**14 (12)**	**15 (73)**	**Overall frequency**	**Overall percentage (95% CI)**
Symptoms																	
Frequent cough	8	2	3	7	2	4	1	1	4	4	0	9	1	1	15	62	16.7 (12.8 to 20.4)
Chronic cough†	3	1	1	7	1	2	0	1	0	1	0	5	0	0	6	28	7.5 (4.9 to 10.2)
Frequent phlegm*	14	7	7	13	3	6	3	1	3	6	1	13	1	1	20	99	26.6 (22.1 to 31.1)
Chronic phlegm†	2	3	2	10	2	5	1	0	2	1	0	7	1	1	11	48	12.9 (9.5 to 16.31)
Frequent wheeze‡	13	6	9	11	2	10	5	6	5	3	0	27	7	3	41	148	39.8 (34.8 to 44.7)
Chronic wheeze†	3	4	4	8	2	3	2	3	5	1	0	17	4	2	25	83	22.3 (18 to 26.5)
Shortness of breath grade 1§	19	10	15	19	4	9	7	4	6	1	7	25	6	6	36	174	46.8 (41.7 to 51.8)
Shortness of breath grade 2¶	9	7	6	6	2	4	4	0	1	1	2	15	2	1	18	78	21 (16.8 to 25.1)
Chest tightness ever**	11	5	9	10	5	6	3	1	5	2	0	21	4	4	38	124	33.3 (28.5 to 38.1)
Chest tightness apart from during cold††	7	1	2	5	4	4	2	0	5	1	0	9	3	2	25	70	18.8 (14.8 to 22.8)
Illnesses																	
Byssinosis‡‡	4	1	0	2	0	0	0	0	0	1	0	5	1	2	23	39	10.5 (7.3 to 13.5)
Asthma§§	4	0	1	1	0	2	0	0	0	0	0	4	0	0	3	15	4 (2 to 6)
Lung function¶¶																	
FEV_1	94	96	94	93	84	91	96	103	104	93	87	83	101	98	102	94 (17.9)***	3.6 (<0.001)†††
FVC	100	100	98	99	90	99	101	104	106	99	90	92	102	104	111	100 (17.5) ***	3.7 (<0.001) †††
FEV_1/FVC¶¶	97	99	100	99	95	97	99	104	101	97	99	94	104	98	95	97 (10.4) ***	1.7 (0.049)†††

*Question asked: do you usually cough/bring up phlegm 5 or more days of the week?
†Chronic applies for symptoms present for more than 2 years.
‡Question asked: does your chest ever sound wheezy or whistling?
§Question asked: are you troubled by shortness of breath when hurrying on level ground, or walking up a slight hill?
¶Question asked: do you have to walk slower than people of your age, on level ground, because of breathlessness?
**Question asked: does your chest ever feel tight and/or your breathing becomes difficult?
††Question asked: does your chest feel tight and/or your breathing becomes difficult occasionally apart from cold?
‡‡Based on Schilling's criteria.
§§Question asked: has a doctor ever told you that you have asthma?
¶¶Lung function: mean percentage-predicted lung volumes at each mill.
***Overall lung volumes at all 15 mills (±SD).
†††ANOVA results: F (p value).
FEV_1, Forced Expiratory Volume in the first second; FVC, Forced Vital Capacity.

Table 3 Multivariate analysis for predictors of respiratory symptoms among male textile workers (n=372), Karachi, Pakistan

Variable	Frequent cough AOR (95% CI)	Chronic cough AOR (95% CI)	Frequent phlegm AOR (95% CI)	Chronic phlegm AOR (95% CI)	Frequent wheeze AOR (95% CI)	Wheeze with shortness of breath AOR (95% CI)	Breathlessness grade 1 AOR (95% CI)	Breathlessness grade 2 AOR (95% CI)	Chest tightness ever AOR (95% CI)	Chest tightness apart from during cold AOR (95% CI)
Section of mill										
Weaving	1	1	1	1	1	1	1	1	1	1
Spinning	0.6 (0.2 to 1.3)	0.7 (0.2 to 2.0)	0.5 (0.2 to 0.9)	0.8 (0.3 to 1.7)	2.0 (1.1 to 3.5)	1.8 (1.0 to 3.4)	0.7 (0.4 to 1.3)	1.0 (0.5 to 1.9)	1.6 (0.9 to 2.8)	1.1 (0.5 to 2.2)
Pack-years of smoking										
Non-smokers	1	1	1	1	1	1	1	1	1	1
Less than 10 years	0.7 (0.4 to 1.4)	0.8 (0.3 to 1.9)	1.4 (0.8 to 2.3)	1.6 (0.8 to 3.1)	1.4 (0.9 to 2.3)	1.3 (0.8 to 2.3)	1.5 (0.9 to 2.4)	1.2 (0.7 to 2.1)	1.1 (0.7 to 1.8)	1.0 (0.6 to 1.9)
More than 10 years	1.0 (0.3 to 2.9)	0.8 (0.1 to 4.0)	3.0 (1.2 to 7.5)	2.2 (0.7 to 6.7)	7.5 (2.7 to 20.5)	2.2 (0.9 to 5.8)	2.0 (0.8 to 4.8)	0.9 (0.3 to 2.5)	2.0 (0.8 to 4.7)	1.8 (0.6 to 4.7)
Duration of work										
Less than 5 years	1	1	1	1	1	1	1	1	1	1
6–10 years	1.3 (0.6 to 2.8)	1.1 (0.4 to 3.0)	0.8 (0.4 to 1.4)	0.9 (0.4 to 2.2)	1.2 (0.6 to 2.0)	1.5 (0.8 to 2.8)	1.6 (0.9 to 2.7)	1.9 (0.9 to 3.8)	1.1 (0.6 to 2.0)	1.3 (0.6 to 2.7)
11 years or more	1.7 (0.8 to 3.5)	1.23 (0.4 to 3.3)	0.6 (0.3 to 1.2)	1.4 (0.6 to 3.1)	0.5 (0.3 to 1.0)	1.0 (0.5 to 2.0)	1.8 (1.0 to 3.1)	2.7 (1.3 to 5.4)	1.4 (0.8 to 2.5)	1.5 (0.7 to 3.0)
Educational status										
Educated	1	1	1	1	1	1	1	1	1	1
Uneducated	0.9 (0.5 to 1.8)	1.6 (0.6 to 3.7)	0.8 (0.4 to 1.4)	0.6 (0.3 to 1.4)	2.0 (1.2 to 3.3)	1.1 (0.6 to 2.0)	1.4 (0.9 to 2.4)	1.1 (0.6 to 2.0)	1.2 (0.7 to 2.0)	1.4 (0.7 to 2.5)
Household income per person*										
High	1	1	1	1	1	1	1	1	1	1
Low	0.6 (0.2 to 1.5)	0.4 (0.1 to 1.7)	0.7 (0.3 to 1.5)	0.5 (0.2 to 1.7)	1.3 (0.6 to 2.6)	1.0 (0.4 to 2.2)	0.9 (0.5 to 1.8)	0.7 (0.3 to 1.5)	0.9 (0.5 to 1.8)	1.0 (0.4 to 2.2)
Lower	0.7 (0.3 to 1.7)	0.6 (0.2 to 2.1)	0.6 (0.3 to 1.3)	1.1 (0.4 to 2.7)	1.8 (0.9 to 3.6)	1.3 (0.6 to 2.8)	1.0 (0.5 to 1.8)	0.8 (0.4 to 1.8)	0.7 (0.3 to 1.4)	1.1 (0.5 to 2.5)
Least	1.5 (0.7 to 3.2)	1.2 (0.4 to 3.4)	1.3 (0.7 to 2.5)	1.2 (0.5 to 2.8)	2.3 (1.2 to 4.5)	1.8 (0.8 to 3.7)	1.1 (0.6 to 2.0)	1.2 (0.6 to 2.4)	1.3 (0.7 to 2.5)	1.6 (0.7 to 3.5)
Ethnicity										
Punjabi	1	1	1	1	1	1	1	1	1	1
Sindhi	2.3 (0.9 to 5.6)	1.3 (0.3 to 4.6)	1.4 (0.6 to 3.1)	1.1 (0.4 to 2.8)	1.8 (0.9 to 3.6)	1.1 (0.5 to 2.4)	1.4 (0.7 to 2.7)	1.4 (0.6 to 3.1)	1.4 (0.7 to 2.8)	2.7 (1.1 to 6.6)
Others	1.1 (0.5 to 2.4)	1.0 (0.3 to 2.8)	1.0 (0.5 to 1.8)	0.6 (0.3 to 1.4)	1.7 (0.9 to 3.1)	1.0 (0.5 to 1.9)	0.9 (0.5 to 1.6)	1.1 (0.6 to 2.2)	1.2 (0.7 to 2.2)	1.7 (0.8 to 3.7)

For each health outcome (respiratory symptom), the multivariate model included all the variables listed in the table. Marital status, mill cluster, age and weight were excluded as they became non-significant in the final multivariate models.
*Calculated by dividing the monthly household income in Pakistani rupees (Rs) (US$1=90 Rs) by number of household members. The continuous variable was later categorised into quartiles where; high >Rs 2553, low=Rs: 1714–2553, lower=Rs: 1157–1714, and least <Rs: 1157.

Table 4 Multivariate analysis for predictors of obstructive pattern* of spirometry among male textile workers (n=372), Karachi, Pakistan

Variable	n: Obstructive pattern	n: No obstructive pattern	AOR	95% CI
Pack-years of smoking				
Non-smoker	15	200	1	–
Less than 10 years	10	120	1.0	(0.4 to 2.4)
More than 10 years	7	20	2.4	(0.8 to 7.7)
Duration of work				
Less than 5 years	7	111	1	–
6–10 years	6	126	0.8	(0.2 to 2.5)
11 years or more	19	103	2.6	(0.9 to 6.9)
Section of mill				
Weaving	13	185	1	–
Spinning	19	155	2.5	(1.0 to 6.2)
Socioeconomic status†				
High	5	88	1	–
Low	5	89	0.8	(0.2 to 3.1)
Lower	13	79	2.7	(0.8 to 8.3)
Least	9	84	1.8	(0.5 to 5.9)
Ethnicity				
Punjabi	12	91	1	–
Sindhi	10	106	0.5	(0.1 to 1.5)
Others	10	143	0.5	(0.2 to 1.2)

Marital status, mill cluster, household income per person and educational status were excluded as they became non-significant in the final multivariate model.

*Obstructive pattern: percentage-predicted $FEV_1/FVC<0.7$, percentage-predicted $FEV_1<80\%$.

†Calculated by dividing the monthly household income in Pakistani rupees (Rs) (US$1=90 Rs) by number of household members. The continuous variable was later categorised into quartiles based on monthly household income per household member, where high >Rs: 2553, low=Rs: 1714–2553, lower=Rs: 1157–1714, and least <Rs: 1157.

FEV_1, Forced Expiratory Volume in the first second; FVC: Forced Vital Capacity.

4% in the weaving section. These findings are comparable with the study by Farooque *et al* which found a prevalence of 19.28% for byssinosis among workers in the cotton spinning mills of Karachi.[15] The study by Memon *et al* found a higher overall prevalence of byssinosis compared with this study, that is, 35.6% among spinning and weaving textile workers of Karachi. Methodological limitations in the sampling technique, and non-use of a standard questionnaire and spirometry by Memon *et al* could explain differences in the findings. However, the distribution of byssinosis according to the section of mill—higher prevalence in the spinning (59.2%) compared with the weaving section (31.9%)[16]—reported by Memon *et al* is similar to this study. A higher proportion of workers at mills 1, 4, 12 and 15 reported respiratory symptoms. Possible reasons could include the fact that these mills were the dirtiest among them all, as observed by the study team. However, it could also be an artefact of the sampling, since the majority of workers in these mills belonged to the spinning section.

In multivariate analysis, we found that the spinning section of textile mills was consistently associated with most of the respiratory symptoms, including frequently reported wheeze, chronic wheeze and chest tightness. Work in the spinning section was also associated with an obstructive pattern of spirometry. It is known that dust concentrations are higher in initial processes in textile industries involving cruder forms of cotton;[15 16] it has also been shown that concentrations of Gram-negative bacterial endotoxins—thought to be the aetiological agents of byssinosis—are also higher in the initial processing. Therefore, workers employed in these sections are more likely to suffer from byssinosis compared with other sections.[31] Endotoxins are a component of the outer membrane of Gram-negative bacteria,[32] and recent research has shown that although their presence increases the risk of respiratory illnesses, like byssinosis, conversely, such exposure protects from atopic asthma, allergies, lung cancer and possibly liver cancer.[32–34]

Textile workers have been reported to be at an increased risk for asthma, with a very high prevalence ranging from 32% to 57%.[26 35 36] However, the textile industry is considered as a mixed environment in terms of exposure to asthmagens, and the risk of asthma is higher only in certain sections of the industry, for instance, the dyeing section.[37] By contrast, the recent review by Liebers *et al* has also suggested that endotoxins present in cotton dust may protect textile workers from atopic asthma.[34] This study found a comparatively low prevalence of asthma among textile workers in Karachi, that is, 4%. Nonetheless, the prevalence in our study is comparable with 6% reported by Farooque *et al.*[15] This prevalence is also low compared with available estimates of 4.3% for asthma in the general population of Pakistan.[38] Although results regarding asthma are consistent with the previous study conducted in Pakistan, we consider that further investigation needs to be carried out to understand this low prevalence of asthma among

Table 5 Multivariate linear regression analysis for predictors of lung function among male textile workers (n=372), Karachi, Pakistan

Variable	Percentage-predicted FEV_1: Value (%)	SE	95% CI	Percentage-predicted FVC: Value (%)	SE	95% CI	Percentage-predicted FEV_1/FVC: Value (%)	SE	95% CI
Duration of work	−0.5	0.1	(−0.9 to −0.2)	−0.3	0.1	(−0.6 to 0.06)	−0.29	0.1	(−0.5 to −0.07)
Pack-years of smoking	0.009	0.16	(−0.3 to 0.3)	0.3	0.1	(−0.000 to 0.6)	−0.2	0.09	(−0.4 to 0.02)
Educational status									
Educated	–		–						
Uneducated	−5.3	3.0	(−11.4 to 0.7)	−4.6	2.9	(−10.4 to 1.1)	−1.1	1.8	(−4.8 to 2.5)
Section of mill									
Weaving	–		–						
Spinning	0.6	2.7	(−4.8 to 6.1)	0.3	2.6	(−4.8 to 5.6)	0.2	1.6	(−3.1 to 3.5)

For each of the three lung function indices, the multivariate model included all the variables listed in the table. Marital status, household income per person, mill cluster and ethnicity were excluded, as they became insignificant in the final multivariate models.

R^2 values: FEV_1=8.5%, FVC=4.7%, Ratio=10.6%.

FEV_1: Forced Expiratory Volume in the first second; FVC: Forced Vital Capacity.

textile workers in Pakistan. It may be that the textile environment is protecting workers from asthma in Pakistan, as has been suggested in the recent study cited above.[34]

Our study reports pack-years of smoking (≥10 years) to be associated with a higher risk of frequently reported phlegm and wheeze; these findings are comparable with a study conducted among Lancashire textile weavers which found smoking to be associated with chronic phlegm production, persistent cough and wheezing after adjusting for confounders. However, our study did not find association of smoking with shortness of breath, as was reported by the Lancashire study.[9]

After adjusting for age and other covariates, duration of work ≥11 years was associated with shortness of breath grade 1 and grade 2, as well as decrement in lung function indices. Similar findings have also been reported by studies conducted among cotton textile workers in Ethiopia and China.[3 39] Our study found that the uneducated were two times more likely to report wheezing as compared with the educated. Memon *et al* also found that uneducated textile workers in Karachi were 3.27 times more likely to report byssinosis as compared with those having intermediate or higher education.[16] Lack of education may be associated with behaviour characteristics at work leading to higher exposures among such individuals. It may also be related to their socioeconomic circumstances, which may predispose them to several other risk factors, such as indoor air pollution due to use of cheap fuel, or lack of access to medical care and so on. We have not been able to adjust for these factors in our study.

This study with robust methodology and measurement techniques, and an adequate sample size, is a significant contribution to the sparse literature regarding respiratory illnesses and symptoms among textile workers from Pakistan. Previous studies have either focused on byssinosis alone,[16] or have methodological limitations, such as a small sample or inappropriate sampling technique.[15 17 18] This study considered broader aspects of respiratory illness and symptoms to reflect the true burden among textile workers in Pakistan. However, certain limitations need to be considered for this study. For exposure measurement, proxy measure of work in the spinning section was used as actual measurements of cotton dust, and endotoxins levels were not possible to obtain due to time and budget constraints. Since this is a cross-sectional study, it could not account for workers who became ill during their work at textile mills and quit their job resulting in a healthy worker selection effect, which is a major limitation of this study. A high turnover has been demonstrated among textile workers in Turkey, where work-related respiratory symptoms were found to predict early leaving from the mill environment;[40] therefore, the prevalence reported in the current study to an extent is an underestimate. The low prevalence of asthma reported in our study could also be due to healthy worker effect or pre-employment selection. Furthermore, this would also account for the findings of an increase in some of the spirometry values with spinning and smoking (table 5).

Participants with at least 1 year of work experience in textile mills were included in the study; however, respiratory illnesses may take longer to develop, and this may have led to an underestimation. Reporting bias could have affected results of our study; however, data collectors were extensively trained in order to minimise this bias. Due to logistic issues, we were not able to capture across-shift and across-week variation in lung function indices; however, for each worker, spirometry was conducted uniformly during working hours after exposure to cotton dust on the same day.

We included textile mills from all major industrial zones in Karachi and suburbs. Thus, we were able to capture a diverse population working in textile units, with varying worker and environmental safety mechanisms, and belonging to various socioeconomic and ethnolinguistic groups. However, we did not include workers from the informal sector where they may be exposed to even higher levels of cotton dust and lack of safety mechanisms. Therefore, the results may be generalised to a similar population of textile workers in Pakistan and other developing countries.

CONCLUSIONS

This study highlights the patterns of respiratory illnesses considering all types of respiratory illnesses and symptoms among textile workers of Karachi, pointing towards dismal occupational safety and health conditions in the largest city and industrial hub of the country. Results show a high prevalence of various respiratory illnesses and symptoms including chest tightness, shortness of breath, byssinosis and others. This study found a low prevalence of asthma among textile workers in Pakistan, a finding which warrants further investigation. Workers in the spinning section, those who were uneducated, with prolonged duration of work and of Sindhi ethnicity, were more at risk of developing one or more of the respiratory conditions. This study may help in future research towards identification of possible interventions to help reduce the burden of respiratory illnesses and symptoms among textile workers.

Acknowledgements We acknowledge funding received from the University of Alabama at Birmingham (UAB) International Training and Research in Environmental and Occupational Health (ITREOH) programme, grant number 5D43TW005750-08, of the Fogarty International Centre of the National Institutes of Health and NASA. The content is solely the responsibility of authors, and does not necessarily represent the official views of the UAB, Fogarty International Centre, or the National Institutes of Health. We are grateful to Mr Faisal Moin Quraishi for his exceptional support in facilitating access to various textile mills that participated in this study. We would like to thank the administration and staff at various textile mills for facilitating our work. We would like to thank Mr Junaid Ahmed, Mr Qurban Ali, Dr Aysha Zahidie and Dr Zaineb Parvez for their contribution in field work and data management. We would like to thank Dr Muhammad Irfan for reviewing spirograms, and Dr David Coggon for his supervisory role in reviewing data analysis and the final manuscript. We would also like to acknowledge the time and effort of the study participants for conducting spirometry, and thank them for providing valuable information.

Contributors All authors were directly responsible for the concept and design, analysis and interpretation of data, drafting and revising of the manuscript, and have approved the manuscript as submitted, and take full responsibility for the work being reported. Also, the acknowledged contributors have agreed to inclusion of their names.

Funding University of Alabama at Birmingham (UAB), grant number 5D43TW005750-08.

Competing interest None.

Patient consent Obtained.

Ethics approval Ethics Review Committee at Aga Khan University.

Provenance and peer review Not commissioned; externally peer reviewed.

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Pattern and predictors for respiratory illnesses and symptoms and lung function among textile workers in Karachi, Pakistan

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Occup Environ Med published online November 15, 2012
doi: 10.1136/oemed-2011-100561

Notes