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Original Article

Comparative Analysis of Textile Factory Workers With Frequency of Byssinosis and Its Relation With the Use of Personal Protective Measures and Workplace Hygiene

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ABSTRACT

Background: Textile workers exposed to cotton dust may develop byssinosis, respiratory symptoms, and impaired pulmonary function, particularly where workplace hygiene and respiratory protection are inadequate. Objective: To determine the frequency of byssinosis among textile factory workers in Lahore and compare pulmonary function between workers with and without byssinosis. Methods: This analytical cross-sectional study included 356 workers from spinning, weaving, dyeing, stitching, and administrative departments. Respiratory symptoms, smoking, employment duration, personal protective practices, and workplace hygiene were assessed using an interviewer-administered questionnaire. Spirometry included FEV_1, percent-predicted FEV_1, FVC, FEV_1/FVC, and peak expiratory flow. Group differences were evaluated using independent-samples comparisons. Results: Byssinosis was identified in 139 workers (39.0%; 95% CI: 34.1–44.2%). Personal protective measures were used by 52 (14.6%), and 65 (18.3%) worked under good hygiene conditions. Compared with workers without byssinosis, affected workers had lower FEV_1 (2.49 ± 0.49 vs 3.19 ± 0.31 L), percent-predicted FEV_1 (67.91 ± 10.23% vs 88.75 ± 6.91%), FVC (3.23 ± 0.58 vs 3.96 ± 0.45 L), FEV_1/FVC (77.12 ± 5.97% vs 80.88 ± 4.75%), and peak expiratory flow (4.69 ± 1.04 vs 6.00 ± 0.94 L/s); all $p < 0.001$. Conclusion: Byssinosis was frequent and associated with substantial pulmonary-function impairment. Improved occupational exposure control, respiratory surveillance, and protective practices are warranted. Keywords: Byssinosis; cotton dust; textile workers; occupational respiratory disease; pulmonary function; spirometry; workplace hygiene; personal protective equipment.

INTRODUCTION

Pakistan is a major cotton-producing country, and its textile industry employs a substantial workforce across cotton processing, spinning, weaving, dyeing, stitching, and finishing operations. Workers engaged in these processes may experience prolonged exposure to airborne cotton dust, fibres, microorganisms, and endotoxins, particularly where ventilation, dust-control systems, housekeeping practices, and respiratory protection are inadequate. Previous research conducted in Pakistani textile settings has documented substantial cotton-dust exposure, limited occupational safety measures, frequent respiratory symptoms, and impaired pulmonary function among exposed workers (1,2).

Byssinosis is an occupational respiratory disorder associated with the inhalation of cotton, flax, hemp, and other vegetable dusts. It is classically characterized by chest tightness, cough, wheezing, or dyspnoea that becomes most pronounced on the first working day after a period away from exposure and may improve during the subsequent working days. With continued or intense exposure, symptoms may

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extend throughout the working week and may be accompanied by persistent airflow limitation or chronic bronchitic manifestations (3–5). Although its clinical presentation may resemble occupational asthma, byssinosis represents a distinct work-related respiratory condition associated with organic dust exposure and characteristic temporal changes in symptoms (6–8).

The occurrence and severity of respiratory impairment among textile workers are influenced by several interacting factors, including airborne dust concentration, duration of employment, specific manufacturing processes, smoking, workplace ventilation, general hygiene, and the consistent use of appropriate respiratory protective equipment. Cotton preparation, opening, carding, spinning, and weaving may generate particularly high concentrations of respirable and inhalable dust, although meaningful exposure may also occur during dyeing, stitching, finishing, cleaning, and material handling. Epidemiological studies have reported a greater frequency of cough, breathlessness, chest tightness, chronic bronchitis, reduced forced expiratory volume in one second, and other spirometric abnormalities among workers exposed to cotton dust than among less-exposed or unexposed populations (2,3,9–11).

Evidence from Pakistan has similarly demonstrated a high burden of respiratory symptoms among textile workers. Studies conducted in Karachi and Faisalabad have identified associations between occupational dust exposure, work location, inadequate safety conditions, and reduced pulmonary function (1,2,12). Nevertheless, the prevalence of byssinosis varies considerably across studies because of differences in industrial processes, dust concentrations, exposure duration, smoking patterns, diagnostic criteria, symptom questionnaires, and pulmonary-function assessment procedures (3,10,12). These variations highlight the importance of evaluating workers within their specific occupational setting while considering both individual and workplace-related factors.

Despite the economic importance of the textile industry, respiratory protection and workplace dust-control practices remain inconsistently implemented in many resource-constrained settings. Limited use of appropriate respiratory protective equipment, poor housekeeping, inadequate ventilation, and a lack of systematic occupational surveillance may increase workers' cumulative exposure to cotton dust. However, locally relevant evidence describing the combined burden of byssinosis, respiratory symptoms, pulmonary-function impairment, workplace hygiene, and personal protective practices among textile workers in Lahore remains limited.

The present study therefore aimed to determine the frequency of byssinosis among textile factory workers in Lahore and to compare pulmonary-function parameters between workers with and without byssinosis. It also evaluated respiratory symptoms, personal protective-equipment use, workplace hygiene, smoking status, job duration, and departmental work location as occupational factors relevant to the occurrence of byssinosis.

MATERIALS AND METHODS

An analytical cross-sectional study was conducted over a three-month period among textile factory workers in Lahore, Pakistan. The target population comprised workers employed in the spinning, weaving, dyeing, stitching, and administrative sections of the participating textile workplace. A total of 356 workers were selected through simple random sampling from the available workforce and underwent interviewer-administered respiratory assessment and spirometry. Workers represented different levels and patterns of occupational exposure according to their assigned department and job responsibilities.

Data were collected using a structured questionnaire adapted from the British Medical Research Council respiratory questionnaire. Trained interviewers obtained information regarding age, sex, height, duration of employment in the textile industry, departmental assignment, smoking status, respiratory symptoms, use of personal protective measures, and general workplace conditions. Smoking status was classified as current smoker, former smoker, or nonsmoker. Respiratory symptoms assessed during the interview included cough, sputum or phlegm production, chest tightness, and shortness of breath. Work-related timing and variation in symptoms were specifically explored to distinguish the characteristic presentation of byssinosis from nonspecific respiratory complaints.

Byssinosis was identified on the basis of a characteristic history of chest tightness, cough, or dyspnoea that was most pronounced on the first working day following the weekend or another period away from occupational exposure and that improved during the subsequent working days. Workers with respiratory symptoms that did not characteristically worsen on returning to work after the weekly break were categorized as having nonspecific work-related respiratory symptoms rather than classical byssinosis. The severity of ventilatory impairment among workers classified as having byssinosis was assessed using percent-predicted forced expiratory volume in one second. A percent-predicted FEV_1 of at least 80% represented no substantial ventilatory impairment, values of 60–79% represented mild-to-moderate impairment, and values below 60% represented severe impairment. Clinical assessment and spirometric interpretation were considered together because respiratory symptoms alone may overlap with occupational asthma, chronic bronchitis, smoking-related disease, and other work-related respiratory disorders (6–8).

Pulmonary function was assessed by spirometry. The recorded parameters included forced vital capacity in litres, forced expiratory volume in one second in litres, percent-predicted FEV_1, the FEV_1/FVC ratio expressed as a percentage, and peak expiratory flow. Each participant received instructions regarding the required forced expiratory manoeuvre before testing. Spirometric measurements were used to describe pulmonary function in the full cohort and to compare workers classified as having byssinosis with those who did not meet the study definition of byssinosis. The pulmonary-function findings were also compared across the spinning, weaving, dyeing, stitching, and administrative sections to identify departmental variation potentially related to differing occupational-exposure patterns.

Personal protective practices were assessed by asking workers whether they used any protective measure intended to reduce the inhalation of cotton dust while performing their routine duties. The type of covering observed or reported, including the use of cloth over the nose and mouth, was documented as part of the workplace assessment. General workplace hygiene was evaluated according to the observed working environment, including the apparent accumulation of dust, cleanliness of the work area, and the availability of conditions intended to reduce airborne exposure. Workplace conditions were subsequently categorized as good or poor for descriptive and comparative analysis.

The principal outcome was the presence of byssinosis. Secondary outcomes included respiratory symptoms and spirometric indices, including FEV_1, percent-predicted FEV_1, FVC, FEV_1/FVC, and peak expiratory flow. Occupational and participant-related variables included departmental assignment, job duration, smoking status, use of personal protective measures, and workplace-hygiene category. Workers classified as having byssinosis were compared with workers who did not meet the diagnostic definition. The latter were described as workers without byssinosis rather than healthy controls because the absence of byssinosis did not exclude other respiratory symptoms or disorders.

Data were entered, cleaned, and analysed using IBM SPSS Statistics version 20.0. Categorical variables were summarized as frequencies and percentages, whereas continuous variables were summarized as means and standard deviations after assessment of their distributions. Independent-samples Student's t-tests were used to compare continuous variables between workers with and without byssinosis. One-way analysis of variance was used to compare spirometric parameters across occupational departments, followed by post hoc pairwise comparisons where an overall group difference was identified. Associations between categorical variables were assessed using the chi-square test. All tests were two-sided, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 356 textile factory workers were included in the analysis. Of these, 119 (33.4%) worked in weaving, 90 (25.3%) in stitching, 74 (20.8%) in spinning, 63 (17.7%) in dyeing, and 10 (2.8%) in administration. The mean age of the participants was 35.84 ± 8.63 years, and the mean duration of employment in the textile industry was 10.03 ± 5.75 years. Current smokers accounted for 156 (43.8%) participants, while 43 (12.1%) were former smokers and 157 (44.1%) had never smoked. Personal protective measures were used by 52 (14.6%) workers, and 65 (18.3%) workers were classified as working under good workplace-hygiene conditions.

Table 1. Demographic, occupational, and workplace characteristics of textile workers

Characteristic	Total, n (%) or mean ± SD	95% CI
Total participants	356 (100.0)	
Age, years	35.84 ± 8.63	
Height, inches	65.36 ± 2.89	
Employment duration, years	10.03 ± 5.75	
Occupational department		
Spinning	74 (20.8)	16.9–25.3
Weaving	119 (33.4)	28.7–38.5
Dyeing	63 (17.7)	14.1–22.0
Stitching	90 (25.3)	21.0–30.0
Administration	10 (2.8)	1.5–5.1
Smoking status		
Never smoker	157 (44.1)	39.0–49.3
Former smoker	43 (12.1)	9.1–15.9
Current smoker	156 (43.8)	38.8–49.0
Personal protective measures used	52 (14.6)	11.3–18.7
Good workplace-hygiene conditions	65 (18.3)	14.6–22.6

Values are presented as n (%) or mean ± SD. Confidence intervals for proportions were calculated using the Wilson method. CI: confidence interval; SD: standard deviation.

The overall mean FEV_1 was 2.92 ± 0.52 L, while the mean percent-predicted FEV_1 was 80.62 ± 13.17%. The mean FVC was 3.68 ± 0.62 L, the mean FEV_1/FVC ratio was 79.41 ± 5.57%, and the mean peak expiratory flow was 5.49 ± 1.17 L/s.

Table 2. Overall pulmonary-function measurements among textile workers

Pulmonary-function parameter	Mean ± SD	Minimum	Maximum
FEV_1, L	2.92 ± 0.52	1.47	3.98
Percent-predicted FEV_1, %	80.62 ± 13.17	35	115
FVC, L	3.68 ± 0.62	2.17	5.52
FEV_1/FVC ratio, %	79.41 ± 5.57	49	93
Peak expiratory flow, L/s	5.49 ± 1.17	3.02	7.73

FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; SD: standard deviation.

Byssinosis was identified in 139 of the 356 workers, corresponding to a prevalence of 39.0% (95% CI: 34.1–44.2%). The remaining 217 workers did not meet the study definition of byssinosis. Workers with byssinosis had substantially lower pulmonary-function measurements than workers without byssinosis.

Mean FEV_1 was 2.49 ± 0.49 L among workers with byssinosis compared with 3.19 ± 0.31 L among those without byssinosis. The mean between-group difference was 0.70 L (95% CI: 0.61–0.79; $p < 0.001$), with a large standardized effect size (Hedges' g = 1.79). Percent-predicted FEV_1 was also markedly lower among workers with byssinosis, with a mean difference of 20.84 percentage points (95% CI: 18.90–22.78; $p < 0.001$; Hedges' g = 2.49).

Mean FVC was 3.23 ± 0.58 L among workers with byssinosis and 3.96 ± 0.45 L among workers without byssinosis, producing a mean difference of 0.73 L (95% CI: 0.62–0.84; $p < 0.001$; Hedges' g = 1.44). The FEV_1/FVC ratio was lower by 3.76 percentage points among workers with byssinosis (95% CI: 2.58–4.94;

p < 0.001), while peak expiratory flow was lower by 1.31 L/s (95% CI: 1.10–1.52; p < 0.001). These differences represented moderate-to-large standardized effects.

Table 3. Comparison of pulmonary function and participant characteristics according to byssinosis status

Variable	Without byssinosis (n = 217), mean ± SD	With byssinosis (n = 139), mean ± SD	Mean difference[1]	95% CI	p-value	Hedges' g
FEV_1, L	3.19 ± 0.31	2.49 ± 0.49	0.70	0.61 to 0.79	<0.001	1.79
Percent-predicted FEV_1, %	88.75 ± 6.91	67.91 ± 10.23	20.84	18.90 to 22.78	<0.001	2.49
FVC, L	3.96 ± 0.45	3.23 ± 0.58	0.73	0.62 to 0.84	<0.001	1.44
FEV_1/FVC ratio, %	80.88 ± 4.75	77.12 ± 5.97	3.76	2.58 to 4.94	<0.001	0.71
Peak expiratory flow, L/s	6.00 ± 0.94	4.69 ± 1.04	1.31	1.10 to 1.52	<0.001	1.33
Age, years	35.70 ± 8.59	36.05 ± 8.71	−0.35	−2.20 to 1.50	0.710	−0.04
Height, inches	64.70 ± 4.64	65.99 ± 3.47	−1.29	−2.14 to −0.44	0.003	−0.30
Employment duration, years	9.68 ± 5.60	10.59 ± 5.94	−0.91	−2.15 to 0.33	0.150	−0.16

[1]Mean difference calculated as the mean among workers without byssinosis minus the mean among workers with byssinosis. P-values and 95% confidence intervals were derived using Welch's independent-samples t-test from the reported group sizes, means, and standard deviations. Positive Hedges' g values indicate higher values among workers without byssinosis. CI: confidence interval; FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; SD: standard deviation.

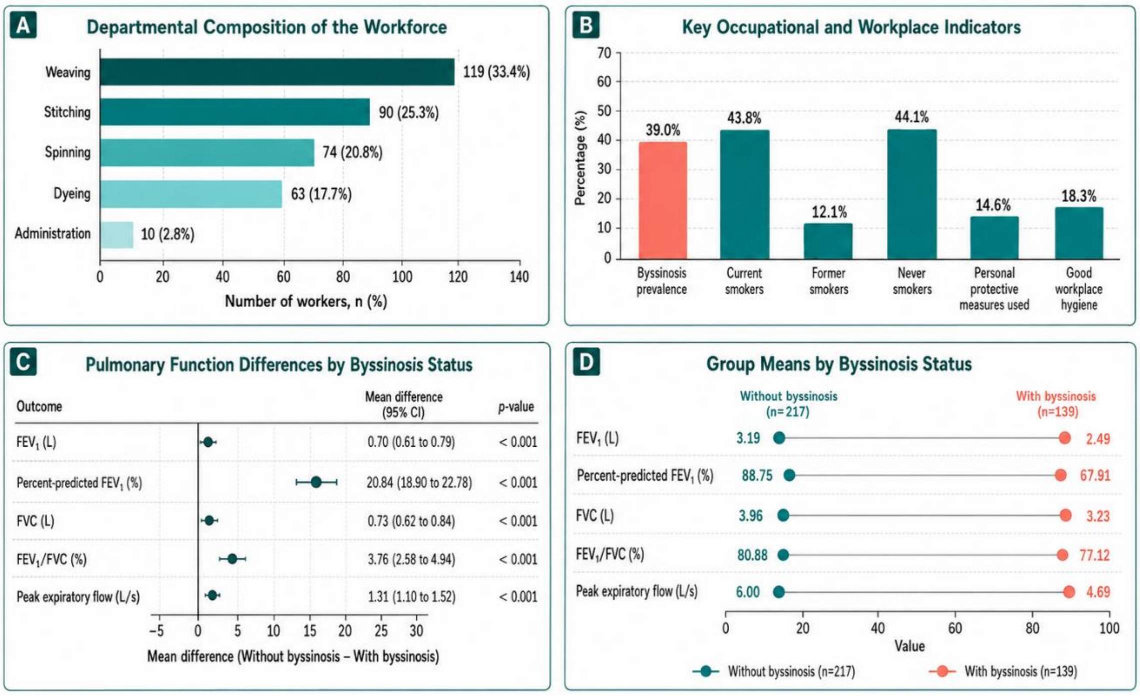

Figure 1 summarizes the occupational profile and respiratory findings of 356 textile workers: weaving was the largest department, byssinosis affected 39.0% of workers, and the use of personal protective measures and good workplace hygiene was low at 14.6% and 18.3%, respectively. Workers with byssinosis had significantly lower FEV_1, percent-predicted FEV_1, FVC, FEV_1/FVC ratio, and peak expiratory flow than those without byssinosis, with all between-group differences reaching $p<0.001$.

The two groups were comparable in age, with no statistically significant difference between workers with and without byssinosis (mean difference −0.35 years; 95% CI: −2.20 to 1.50; p = 0.710). Employment duration was approximately 0.91 years longer among workers with byssinosis, although this difference was not statistically significant (95% CI: −2.15 to 0.33; p = 0.150). Mean height differed modestly between the groups (p = 0.003), but the standardized effect was small (Hedges' g = −0.30).

The manuscript reported departmental variation in pulmonary function. FEV_1, FVC, and peak expiratory flow were lowest among stitching workers, whereas percent-predicted FEV_1 and the FEV_1/FVC ratio were lowest among dyeing workers. However, complete departmental means, overall analysis-of-variance statistics, and post hoc pairwise comparisons were not available in the reported results.

Cough was reported more frequently among workers with byssinosis, with a statistically significant between-group difference ($p = 0.001$). Differences in phlegm production ($p = 0.386$), dyspnoea ($p = 0.290$), and chest tightness ($p = 0.568$) were not statistically significant. Exact symptom frequencies were not incorporated into the revised tables because the counts and percentages reported in different sections of the source manuscript were internally inconsistent.

Overall, byssinosis affected approximately two-fifths of the textile workers. The largest between-group differences were observed for percent-predicted FEV_1, FEV_1, FVC, and peak expiratory flow. Personal protective-measure use and good workplace-hygiene conditions were uncommon; however, the available aggregate results did not provide cross-tabulations or adjusted estimates establishing their independent associations with byssinosis.

DISCUSSION

This analytical cross-sectional study identified byssinosis in 39.0% of 356 textile factory workers in Lahore. Workers classified as having byssinosis demonstrated substantially lower FEV_1, percent-predicted FEV_1, FVC, FEV_1/FVC ratio, and peak expiratory flow than workers who did not meet the study definition. The largest standardized differences were observed for percent-predicted FEV_1, FEV_1, FVC, and peak expiratory flow, indicating that the clinical symptom pattern used to identify byssinosis was accompanied by meaningful pulmonary-function impairment. Personal protective measures were used by only 14.6% of workers, and 18.3% were classified as working under good workplace-hygiene conditions, demonstrating limited implementation of exposure-control practices within the assessed workplace.

The observed byssinosis prevalence was broadly consistent with previous research conducted among cotton and textile workers in South Asia and other resource-constrained industrial settings. Memon et al. documented byssinosis among spinning and textile workers in Karachi, while Nafees et al. reported a substantial burden of respiratory symptoms and impaired lung function among Pakistani textile workers (2,9). Studies from cotton-processing environments in India have similarly demonstrated frequent respiratory symptoms and reduced pulmonary-function measurements among dust-exposed workers (4,5). The prevalence observed in the present study was higher than that reported among workers exposed to hemp and jute in Turkey but somewhat lower than the approximately 44% prevalence reported among cotton-dust-exposed textile workers in Benin (13,14). Differences among studies may reflect variation in airborne dust concentrations, industrial processes, ventilation, exposure duration, workforce characteristics, smoking patterns, diagnostic definitions, questionnaire administration, and the timing and technical quality of spirometry.

Workers with byssinosis had an average FEV_1 that was 0.70 L lower than that of workers without byssinosis. Percent-predicted FEV_1 was lower by 20.84 percentage points, and FVC was lower by 0.73 L. These differences were statistically robust and had large standardized effect sizes. Previous studies have also reported reduced FEV_1 and other spirometric measurements among workers exposed to cotton dust. Anyfantis et al. found lower pulmonary-function measurements and a higher frequency of respiratory symptoms among Greek cotton-industry workers than among comparison participants (3). Dube et al. reported progressive respiratory impairment among cotton-ginning workers, particularly with increasing exposure duration (4). Dangi and Bhise also identified lower FEV_1, FEV_1/FVC, and peak expiratory flow among cotton-mill workers, supporting an association between cotton-dust exposure and obstructive respiratory changes (5).

The FEV_1/FVC ratio was 3.76 percentage points lower among workers with byssinosis, while peak expiratory flow was 1.31 L/s lower. Although the original manuscript classified these differences as statistically nonsignificant, recalculation from the reported group sizes, means, and standard deviations demonstrated p-values below 0.001 for both outcomes. This correction is important because the reported group differences were too large relative to their variability to be compatible with the original p-values.

The lower FEV_1/FVC ratio suggests a greater obstructive component among workers with byssinosis, whereas the reduction in peak expiratory flow indicates impaired expiratory performance. Nevertheless, spirometric interpretation should remain cautious because the manuscript did not identify the reference equations, spirometer model, calibration procedures, acceptability criteria, or timing of testing in relation to the work shift and weekly exposure cycle.

Cotton dust contains plant particles, microorganisms, endotoxins, and other biologically active components capable of triggering airway inflammation and bronchoconstriction. Repeated exposure may result in acute work-related changes in airway calibre and, over time, persistent respiratory symptoms and chronic airflow limitation. Inflammatory responses to organic dust are influenced by endotoxin and other microbial constituents, which may activate epithelial and innate immune pathways (15). The characteristic worsening of symptoms after a period away from work may reflect renewed airway responses on re-exposure, although the biological mechanisms of byssinosis remain incompletely understood. Smoking may amplify these effects by contributing independently to chronic cough, mucus production, airflow limitation, and reduced pulmonary reserve.

Smoking represented an important potential confounder in this study because 43.8% of participants were current smokers and 12.1% were former smokers. Although smoking status was described, the reported analysis did not establish whether smoking was more common among workers with byssinosis or whether the association between occupational factors and byssinosis remained after adjustment for smoking. Previous studies have demonstrated that smoking and occupational dust exposure may jointly influence respiratory symptoms and lung function among textile workers (2,10,11). Future analysis of the original dataset should therefore incorporate smoking status, age, sex, height, department, and employment duration within a multivariable model.

Departmental differences were also reported. FEV_1, FVC, and peak expiratory flow were lowest among stitching workers, whereas percent-predicted FEV_1 and the FEV_1/FVC ratio were lowest among dyeing workers. These findings require cautious interpretation because complete departmental means and post hoc comparisons were unavailable. Departmental work location may serve as an indirect indicator of exposure intensity, but it cannot replace direct measurement of airborne cotton dust or endotoxin. Furthermore, the stitching department included a high proportion of women, creating potential confounding by sex and body size for absolute spirometric measurements. Percent-predicted values may partially account for demographic differences, but the reference equations used in their calculation were not reported.

Cough was the only respiratory symptom reported to differ significantly between workers with and without byssinosis, whereas phlegm production, dyspnoea, and chest tightness did not differ statistically. The high frequency of symptoms in both groups may indicate substantial respiratory morbidity throughout the workforce, but inconsistent symptom counts and percentages in the original manuscript prevented reliable reconstruction of the exact distributions. Similar studies have reported cough, breathlessness, chest tightness, sputum production, and wheezing among cotton-dust-exposed workers (3–5,14). Differences in symptom prevalence may arise from smoking, disease misclassification, interviewer technique, translation of questionnaires, seasonal respiratory illness, and the sensitivity of symptom definitions.

The limited use of personal protective measures and the low proportion of workers classified as having good workplace hygiene are occupationally important observations. Khan et al. reported inadequate safety conditions and high cotton-dust concentrations in Pakistani textile settings, particularly in smaller or less-controlled industrial units (1). Tahir et al. similarly documented elevated cotton-dust exposure in small-scale weaving environments in Punjab (12). Effective prevention should prioritize exposure control at the source through dust extraction, enclosure of dust-generating processes, appropriate ventilation, regular housekeeping, equipment maintenance, and occupational-health surveillance. Respiratory protective equipment should complement, rather than replace, engineering and administrative controls.

The study had several strengths. It included a relatively large sample drawn from multiple textile departments and combined symptom assessment with objective pulmonary-function measurements. It also examined workplace hygiene and protective practices alongside respiratory outcomes, thereby addressing an important occupational-health issue in a major Pakistani industry. The revised analysis further quantified between-group differences using confidence intervals and standardized effect sizes, improving the clinical interpretation of the reported findings.

Several limitations should be considered. The cross-sectional design prevented determination of temporal or causal relationships between workplace exposure and pulmonary impairment. Cotton-dust and endotoxin concentrations were not directly measured, and departmental assignment was used only as an indirect exposure indicator. Workplace hygiene and protective practices were not assessed using a reported validated or reproducible scoring method. Smoking and other important confounders were not controlled through multivariable analysis. The spirometry protocol lacked sufficient technical detail regarding calibration, reference equations, test quality, and work-shift timing. The study did not include a clearly defined external unexposed control group, and the reported simple random sampling method was not described sufficiently to confirm representativeness. Symptom counts were inconsistent across sections, and the ethics approval and informed-consent procedures were not reported. These limitations reduce the precision and generalizability of the findings but do not negate the substantial respiratory burden observed among the participating workers.

Overall, the findings indicate a high frequency of byssinosis and clinically important pulmonary-function impairment among textile workers in the assessed setting. The results support the need for better exposure assessment, occupational respiratory surveillance, workplace dust control, and consistent access to appropriate respiratory protection. Longitudinal studies incorporating quantitative dust monitoring, standardized spirometry, validated workplace assessments, and adjusted statistical models are required to clarify exposure–response relationships and identify modifiable determinants of respiratory impairment.

CONCLUSION

Byssinosis was identified in 39.0% of the textile workers and was associated with substantially lower FEV_1, percent-predicted FEV_1, FVC, FEV_1/FVC ratio, and peak expiratory flow. Personal protective practices and favourable workplace-hygiene conditions were uncommon in the assessed setting. These cross-sectional findings demonstrate a considerable burden of work-related respiratory morbidity and support strengthening occupational exposure control, respiratory surveillance, and appropriate protective practices in textile workplaces.

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