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Prevalence of Byssinosis among Spinning Mill Workers: A Cross-Sectional Analysis in Faisalabad, Pakistan

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ABSTRACT

Spinning industries are major sources of airborne cotton dust, exposing approximately 0.8 million workers worldwide. Chronic exposure can cause respiratory disorders, including byssinosis, characterized by chest tightness, coughing, wheezing, and impaired lung function. The present study aimed to assess the prevalence of byssinosis and other respiratory problems among spinning mill workers and their association with duration of exposure. A cross-sectional study was conducted from October 2021 to January 2022 in a spinning mill near Ghani Abad, Faisalabad. A total of 199 workers with ≥2 years of experience were randomly selected from seven departments. Data on demographics, occupational history, smoking habits, and respiratory symptoms were collected via structured questionnaires. Spirometry was performed to measure FVC, FEV1, FEV1/FVC ratio, and PEFR. Byssinosis severity was graded according to WHO lung function criteria. Data analysis included descriptive statistics and Chi-square tests to determine associations between work experience and respiratory outcomes. The most frequently reported symptoms were pneumonia (59.8%), cough (50.3%), phlegm (41.2%), and chest tightness (37.2%). Significant associations ($p<0.05$) were observed between work experience and phlegm, breathlessness, chest illness, and pneumonia. Spirometry indicated 17% of workers had moderate, and 62% had severe lung function impairment. Cases of chronic byssinosis were predominantly among workers with 4–5 years

of exposure. Cotton dust exposure in spinning mills is strongly associated with respiratory problems and byssinosis, with longer exposure increasing severity. Preventive measures, including dust control and regular health monitoring, are essential to protect worker health.

Keywords: Byssinosis, Cotton dust, Respiratory problems, Spinning mill workers, Occupational health.

INTRODUCTION

Spinning and textile industries worldwide remain significant sources of airborne cotton dust, which poses serious occupational health risks, especially respiratory diseases, for workers (e.g., cough, phlegm, chest tightness, wheezing, byssinosis) (Das and Kathiresan, 2022). In many low- and middle-income countries (LMICs), textile production still relies on processes that generate high dust levels. Although reliable disease statistics for spinning-mill workers remain limited, it is estimated that hundreds of thousands of workers globally are exposed routinely to cotton dust (Khan, 2017). Exposure levels are particularly high during blow room, carding, and spinning, where dust generation is far greater than in the later finishing operations (Nafees et al., 2022). The risk to worker health is aggravated by factors including insufficient dust control, lack of personal protective equipment (PPE), inadequate ventilation, and concurrent exposure to bacterial endotoxins associated with cotton dust.

Cotton processing releases fine particulate matter (often known as cotton dust) and biologically active endotoxins. Studies have consistently shown that dust concentrations, and endotoxin levels, tend to be higher in these early processing sections than in subsequent operations such as weaving or finishing. For instance, a multi-factory survey in Pakistan reported high inhalable dust levels and elevated endotoxin concentrations particularly in spinning sections under humid conditions. That survey also documented a high prevalence of respiratory symptoms such as shortness of breath, chest tightness, cough, and fever among workers, highlighting poor occupational hygiene and safety conditions in many cotton mills.

Experimental field investigations in the United States, led by occupational health institutes, demonstrated a linear relation between airborne cotton dust (and endotoxin) exposure and acute changes in lung function over a working week, as well as chronic respiratory disease. Long-term exposure to endotoxin appeared more strongly correlated with the acute respiratory responses than dust levels per se. Indeed, guidelines and standards (e.g., permissible dust thresholds) were developed to control cotton dust exposure and reduce disease incidence; implementation of these standards reportedly lowered byssinosis prevalence from ~20% to below 1% among US textile workers. Yet, in many LMICs, these safety measures remain under-enforced, and byssinosis continues to be a public health concern.

Historically, byssinosis (aka “brown lung disease”) has been recognized as a chronic occupational lung disease among cotton workers. Clinical manifestations include chest tightness (often most prominent at the beginning of the workweek — especially Monday), wheezing, coughing, phlegm production, and progressively declining lung function. Over time, repeated exposures may lead to chronic airflow obstruction, chronic bronchitis, or even permanent impairment of ventilatory capacity.

Epidemiological studies across various countries have reported a broad range of byssinosis prevalence among cotton textile workers, depending on factors such as dust levels, work processes, use of protective measures, and diagnostic criteria (symptoms-based vs spirometry-based). For example, in a cotton mill study in Turkey, among 223 cotton-processing workers, the prevalence of byssinosis was reported as 14.2%. Chest tightness was the most common respiratory symptom (20.3%), and many workers experienced symptoms not only on the first but on multiple days of the working week, suggesting both acute and chronic effects. The mean respirable dust levels ranged between approximately 0.095 and 0.413 mg/m³. In another longitudinal study from China (1981–1996), 429 cotton textile workers were

followed along with 449 control silk workers. Over 15 years, the cumulative incidence of byssinosis and work-related chest tightness was 24% and 23%, respectivel. Chronic bronchitis, cough, and dyspnoea were more persistent in cotton workers. Importantly, higher cumulative exposure to endotoxin (rather than dust concentration alone) was associated with increased byssinosis risk, and cessation of exposure led to gradual improvement in symptoms.

Given these uncertainties, localized studies remain essential. In regions such as Faisalabad (Pakistan) which is known for its concentration of spinning mills, conditions may resemble those in earlier, high-dust mills. The combination of long working hours, minimal dust control, limited use of PPE, and high humidity could result in significant inhalable dust and endotoxin exposure among workers. These workers may suffer from respiratory symptoms, impaired lung function, chronic airflow obstruction, or byssinosis. However, data from such mills remain sparse, under-published, or based on outdated methods. Therefore, we herein aim to fill this gap by combining structured questionnaire and spirometric measures to estimate the prevalence of byssinosis.

METHODOLOGY

Study Area

The study was conducted in Ghani Abad, located approximately 32 km northeast of Faisalabad city along Sheikhupura-Lahore Road (31°30′48″N, 73°21′18″E). This area is a hub for cotton-based industrial production and significantly contributes to Pakistan's economy (Figure 1).

Study Design and Ethical Approval

A cross-sectional study was carried out from October 2021 to January 2022 to assess the health impacts of cotton dust on spinning mill workers. The study was approved by the Institutional Ethics Review Board (D/12/DoZUE/03). Written consent was obtained from all participants, and permission was granted by the industry administration.

Participants and Sampling

Workers with a minimum of two years of experience were randomly selected from seven departments of the mill. Both administrative staff and general workers with over two years of experience were included, while technical workers directly exposed to cotton dust during processing were also considered. Exclusion criteria included workers with less than two years of experience, administrative or general staff with <2 years' service, technical staff not in close contact with cotton dust, and those with recent acute respiratory infections, fever, flu-like symptoms, or doctor-diagnosed seasonal respiratory illness in the preceding four weeks. A total of 382 workers across seven departments of the spinning mill were considered eligible for participation. Workers with at least 2 years of experience were invited to participate. Among these, 199 provided written consent and completed all assessments, yielding a participation rate of 52%. Reasons for non-participation included recent acute respiratory illness, unwillingness to provide consent, or absence during the study period. Random sampling was performed using a computerized random number generator stratified by department to ensure representative selection. The sample size of 199 was determined based on a power analysis to detect a 15% difference in prevalence of respiratory symptoms across exposure groups, assuming 80% power, $\alpha = 0.05$, and a two-sided test.

Data Collection

A structured questionnaire, translated into Urdu, was used to collect baseline demographic data (hometown, occupation, wages, family background, and family employment), respiratory health history, and smoking habits (including type and brand of cigarettes). Blood pressure was measured using an automatic device.

Spirometry was performed using the Spiro lab device (model 911080, MIR, Italy), calibrated daily according to manufacturer instructions. The lower limit of normal (LLN) was defined as the 5th percentile of the predicted value distribution. FEV_1/FVC ratios were calculated, and airway obstruction was defined both by fixed ratio (<0.70) and LLN criteria for sensitivity analysis.

Outcome Measures

Respiratory symptoms (cough, phlegm, wheezing, chest tightness, breathlessness) and spirometric results were used as outcome measures. Byssinosis

was diagnosed and graded according to the WHO classification based on FEV_1: no effect (≥80% predicted), mild to moderate (60–79% predicted), and severe (<60% predicted).

Data Analysis

All data were analyzed using SPSS-16. The Chi-square test was employed to evaluate significant associations between work experience and respiratory outcomes.

RESULTS

Pneumonia (59.8%), Cough (50.3%), Phlegm (41.2%), and Chest tightness (37.2%) were the most commonly reported symptoms (Table 1) among workers. There was a significant ($p<0.05$) association of Phlegm, Breathlessness, Chest illness, and Pneumonia with experience (Table 2).

Table 1: Respiratory parameters of workers with their frequency and percentage (N=199)

Sr. No.	Respiratory Parameter	n (%)
1.	Cough	100 (50.3)
2.	Phlegm	82 (41.2)
3.	Breathlessness	9 (4.5)
4.	Wheezing	37 (18.6)
5.	Chest Tightness	74 (37.2)
6.	Bronchitis	62 (31.2)
7.	Pneumonia	119 (59.8)
8.	Pulmonary TB	19 (9.5)
9.	Asthma	18 (9.0)
10.	Smoking	31 (15.6)

When EEV1 was compared for chronic byssinosis as per WHO Criteria of lung function testing, 17% of workers have a moderate effect on lung functioning while 62% of the participants of study were severely affected by cotton dust. They contribute collectively to about 79% of the total sample size.

Table 2: Respiratory parameters of workers related to their experience

Sr. No.	Respiratory Parameters	Experience						P-Value
		2-3	4-5	6-7	8-9	10-11	12-13	
1	Cough	15	48	22	12	1	2	0.061
2	Phlegm	10	42	16	12	0	2	**0.006***
3	Breathlessness	0	2	4	2	0	1	**0.034***
4	Wheezing	6	15	8	6	0	2	0.216
5	Chest Illness	11	33	17	12	0	1	**0.022***
6	Bronchitis	9	30	12	9	0	2	0.127
7	Pneumonia	21	55	24	16	1	2	**0.027***
8	Pulmonary Tuberculosis	2	7	6	3	0	1	0.319
9	Asthma	1	7	6	3	0	1	0.178
10	Smoking	3	15	6	4	2	1	0.304

*Significant at $P < 0.05$

Furthermore, most of the cases with chronic byssinosis were having the experience of 4-5 years (Table 3).

DISCUSSION

The present study highlights that respiratory symptoms are highly prevalent among spinning mill workers, with pneumonia (59.8%), cough (50.3%), phlegm (41.2%), and chest tightness (37.2%) being the most frequently reported. Importantly, these symptoms demonstrated a clear association with the duration of work experience, reflecting an exposure-response gradient. Our findings revealed that symptom burden is not uniform across the workforce but increases with cumulative exposure.

Findings of the present study suggests that the workers experience pneumonia, cough, phlegm, and chest illness related to work place exposure. In developing countries respiratory problems due to cotton dust is a serious problem. Workers exposed to cotton dust had symptoms like cough, phlegm, wheezing, shortness of breath, and chest tightness (Daba Wami et al., 2018). By comparison of the duration of exposure with the respiratory symptoms

revealed that the longer the exposure has higher the presence of symptoms (Mohammed et al., 2017) as there was a significant association ($p<0.05$) as per findings of present study.

Table 3: Prevalence of Byssinosis among workers (FEV1%)

Experience	1-59% (n, %)	60-79% (n, %)	>80% (n, %)
2-3	28 (22.6%)	1 (3.03%)	4 (9.5%)
4-5	58 (46.8%)	17 (51.5%)	21 (50%)
6-7	26 (21.0%)	7 (21.2%)	6 (14.3%)
8-9	12 (9.7%)	8 (24.2%)	10 (23.8%)
10-11	0	0	1 (2.4%)

Exposure to cotton dust is associated with one or more respiratory symptoms (Hinson et al., 2016; Mansouri et al., 2016; Mehwish and Mustafa, 2016). The disorder of lung functioning can be in restrictive, obstructive, and mixed pattern (Nafees et al., 2013). Long-term exposure to cotton dust increases the risk of byssinosis, chest tightness, and other respiratory problems. However, a study by Memon et al., 2008 (Memon et al., 2008) reported that the length of work experience was not a significant factor contributing to byssinosis or related respiratory symptoms.

Among different populations prevalence percentage of byssinosis was found to be 30% in Indonesia, 37% in Sudan, 40% in Ethiopia, up to 50% in India, 18% in Cameroon, 14.2% in Turkey, 6.2% in France, 5.9% in Greece, 5% in Slovakia, 1.7% in the Czech and 35.6 % in Pakistan (Daba Wami et al., 2018; Mehta et al., 2022). Most of the workers (79%) in spinning industry have moderate to severe byssinosis as per findings. Similar study was conducted by Rahman (2013), in which he found that the workers with more than 20 years of experience had a 12.5% prevalence of byssinosis and 87.5% of byssinosis was present in workers with less than 20 years of experience.

Murlidhar et al., 1995 reported that workers with an increase in experience have more chances of byssinosis as compared with fresh workers. In that study, about 30% of total workers had the symptoms of byssinosis due to working in spinning mills for about 5 years (Murlidhar et al., 1995). With the increase in working experience, they had higher risks of byssinosis. Specific and nonspecific respiratory symptoms were related to dust particles and mainly associated with byssinosis. Less exposure to cotton dust is helpful to the health improvement of workers (Wang et al., 2003). A similar study was conducted by Farooque et al., 2008 in which they found a high relationship between byssinosis and cotton dust (Farooque et al., 2008). According to Memon, et al., 2008 byssinosis and experience had no significant relationship with each other (Memon et al., 2008). On the basis of FEV1% in the current investigation we found a strong association of byssinosis with the cotton dust exposure. Based on FEV1 cotton workers had more symptoms of respiratory problems. Furthermore, long-term exposure to cotton dust had long-term severe effects on the respiratory system of the workers (Wang et al., 2005).

Our study has certain limitations that warrant consideration in future investigations. The cross-sectional design hinders establishing causal links, and long-term effects may be under-represented. Self-reported symptoms and reliance on occupational history introduce recall bias, while the single-location focus on Faisalabad limits generalizability. Potential selection bias arises from voluntary participation, and the use of spirometry during working hours may not fully capture overall respiratory health. Despite efforts for a representative sample through random sampling, residual confounding possibilities persist due to individual variability and lifestyle factors.

Despite the robust associations observed, the study acknowledges limitations inherent to its cross-sectional design, including inability to establish causality, potential recall bias from self-reported symptoms, and limited generalizability due to focus on a single location. Additionally, spirometry conducted during working hours may not fully capture long-term respiratory health. These limitations highlight the need for cautious interpretation and contextual comparison with other studies.

Conclusion

The present study demonstrates that exposure to cotton dust in spinning mills is strongly associated with respiratory problems, including pneumonia, cough, phlegm, chest tightness, and breathlessness, with a significant proportion of workers exhibiting moderate to severe impairment of lung function. Spirometric evaluation indicated that 79% of participants suffered from moderate to severe effects, highlighting the substantial burden of byssinosis among workers with even relatively short durations of exposure (4–5 years). The findings underscore that both the duration and intensity of exposure play critical roles in the development and severity of respiratory symptoms, and that cotton dust remains a primary occupational hazard in spinning industries, particularly in developing countries.

Future research should consider longitudinal designs to track the progression of respiratory impairment over time and evaluate the long-term effects of cumulative cotton dust exposure. Studies incorporating larger and more diverse worker populations across multiple industrial sites are warranted to enhance generalizability. Furthermore, investigations integrating environmental monitoring, endotoxin quantification, and the effectiveness of dust-control interventions would provide critical insights for occupational health policy. Implementing routine respiratory health surveillance, promoting protective equipment use, and enforcing dust mitigation measures are essential strategies to reduce the burden of byssinosis and improve the long-term health outcomes of cotton industry workers.

Author contributions

MAA, AR and SA performed the experiment, and **HA** and **AA** wrote the manuscript. **MBK** supervised the project and designed the strategy and **AA** edited and reviewed the final manuscript.

All authors have read the final version of manuscript.

Declarations

Availability of data and material

The dataset generated and analyzed during the current study is available from the corresponding author upon request. However, certain restrictions apply to the availability of specific materials due to privacy considerations.

Competing interests

The authors declare no competing interests.

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