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# Respiratory Symptoms and Lung Function among Greek Cotton Industry Workers: A Cross-Sectional Study

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## Abstract

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**Background:** Workers in cotton industry are occupationally exposed to various dust-related hazards. The nature of these agents and the respective exposure levels depend on the cotton industry specific sector. These exposures could be associated with respiratory symptoms and changes in lung function parameters.

**Objective:** To evaluate associations between occupational exposure and respiratory function as well as reported symptoms in several groups of workers at different stages of the cotton industry in a vertical approach that covers all the major sectors—from cotton ginning to weaving and fabric production.

**Methods:** A questionnaire on respiratory symptoms and individual as well as workplace characteristics was completed by 256 workers at the cotton industry and 148 office workers (control group). Both groups underwent spirometry.

**Results:** Workers in cotton industry reported a higher prevalence of severe dyspnea ( $p=0.002$ ) and wheezing ( $p=0.004$ ) compared to the control group. Also they were found to have a lower predicted  $FEV_1\%$  ( $p<0.029$ ) and lower  $FEV_1/FVC$  ( $p<0.001$ ) values. In addition, a higher prevalence of  $FEV_1\% <80\%$  ( $p<0.001$ ) and  $FEV_1/FVC <70\%$  ( $p=0.041$ ) were found among textile workers. Similar results were found for non-smoker textile workers compared to non-smoker control group workers. Those working in cotton ginning mills recorded the highest decrease of spirometric values. Duration of employment in cotton industry and smoking use were found to be predictors of lung function decline for cotton industry workers.

**Conclusion:** Occupational exposure to cotton dust was associated with increased prevalence of respiratory symptoms and obstructive pattern in pulmonary function test.

**Keywords:** Cotton fiber; Occupational exposure; Signs and symptoms, respiratory; Spirometry; Lung diseases; Byssinosis; Greece

## Introduction

Workers in cotton industry are exposed to a variety of air-borne agents, originating from natural fibrous materials and dust in their work

environment.<sup>1</sup> Cotton dust is produced by processing cotton with the use of machines in order to develop textile, fabrics, and final products such as clothes. Exposure of workers to cotton dust in their workplace has been associated with several respira-

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tory symptoms and diseases.<sup>2</sup>

Cotton industry consists of a number of different sectors and discrete stages starting from cotton collection at the field, initial processing in cotton ginning mills, spinning, and weaving up to the production of fabrics and clothes. There are several safety and health issues associated with the cotton industry, either general or specific, for each sub-sector.<sup>3</sup> To the best of our knowledge there is sparse information on the respiratory health of cotton workers in Greece.<sup>4</sup> We therefore conducted the present study to investigate the prevalence of respiratory symptoms and pulmonary function abnormalities in those working in different sectors of cotton industry and compare it with a group of office workers.

## Materials and Methods

The study protocol was approved by the Ethics Committee of the University Hospital of Larissa, Greece. All participants provided written informed consent. The study was conducted in October 2014 including major factories in the region of Larissa, Greece. Those factories covered all the major sectors of cotton industry, including three cotton ginning mills, two spinning mills, two weaving factories, and two factories producing final fabrics and clothes. Apart from a number of small family owned ginning mills, those factories were the main production units in the region. Meetings were held with the factory managers and workers' representatives (usually elected members of the employees' OSH committee) where the nature of the survey was briefly explained. Approval and consent were also obtained at managerial level, work council level, and individual level.

### Environment Setting

All those working in the above-mentioned factories (n=354) were invited to participate in our study. However, many were

working at a night shift, since some of factories were working 24 hours 7 days a week, while some other refused to participate in the study. Workers with temporary respiratory issues caused for example by seasonal flu, were excluded from the study. Of 354 invitees, 262 workers were available and agreed to participate (response rate of 74%); six of them could not perform the spirometry test correctly, leaving a target group to 256 workers. The cotton industry workers were matched on group level with a comparison group of 148 office employees for gender, age, and smoking habits.

During a major preliminary visit, a walkthrough survey of the factory was conducted accompanied with a questionnaire that was given to the workers that included demographics, workplace characteristics, job description, respiratory symptoms (cough, sputum production, dyspnea, wheezing) and temporal changes in symptoms (worse at work or improved during weekends or holidays), smoking habits, use of personal protective equipment, and family and past medical history. Smoking status was measured as pack-years (PYS). Respiratory symptoms were measured in a dichotomous way as "yes/no."

### Spirometry

Spirometry was performed using a desktop spirometer (Spirolab III, MIR, Italy), according to the American Thoracic Society (ATS) recommendations. The spirometric reference values used were those proposed by the European Respiratory Society (ERS-GLI, 2012).<sup>5</sup> Forced expiratory attempts were repeated until three acceptable tests were obtained and the best forced expiratory volume in the first second (FEV1), and forced vital capacity (FVC) were recorded.

During the days that the spirometry tests took place, another questionnaire was filled for each worker by the pulmonologist who inspected the whole process

For more information on respiratory morbidity among Indian tea industry workers see <http://www.theijoem.com/ijoem/index.php/ijoem/article/view/761>



**Table 1:** Comparison of anthropometric characteristics between two studied groups

Variable	Cotton industry workers (n=256)	Office workers (n=148)	p value
Male, n (%)	135 (52.7%)	90 (60.8%)	0.141
Mean (SD) Age, (yrs)	43.4 (8.8)	44.3 (7.6)	0.298
Smokers, n (%)	124 (48.4%)	66 (44.6%)	0.521
Median (IQR) Amount of smoking, (pack-yrs)	4 (0 to 17)	7 (0 to 20)	0.409*
Median (IQR) Duration of employment, (yrs)	15 (8 to 21)	15 (9 to 21)	0.798*

\*Mann-Whitney U test

and made the corresponding diagnosis, which also included the MRC breathlessness scale values,<sup>6</sup> and other symptoms not included in the initial questionnaire.

### Statistical Analysis

Data analyses were performed with SPSS<sup>®</sup> for Windows<sup>®</sup> ver 20.0.  $\chi^2$  test was used to test association between categorical variables. One-sample Kolmogorov-Smirnov test was used to test if distribution of continuous variables was normal. Means of two normally distributed variables were compared with *Student's t* test. Mann-Whitney U test was used to compare variables that did not follow a normal distribution. Multiple linear re-

gression analysis was used to assess the impact of pulmonary function parameters. A two-tailed p value <0.05 was considered statistically significant.

### Results

Almost half of the participants were male and current smokers (Table 1). No significant differences were noted in age and smoking habits between the two groups. Cotton industry workers had a significantly lower predicted FEV<sub>1</sub>% (p=0.016) and FEV<sub>1</sub>/FVC (p<0.001) compared to office workers (Table 2). Cotton industry workers reported more severe dyspnea (p=0.005), and wheezing (p=0.014) compared to the comparison group members (Table 3).

Additionally 9.8% of cotton industry workers were classified at MRC breathlessness Grade 1, 1.2% at Grade 2 and 0.8% at Grade 3 (Table 3).

Similar results were found by analyzing subgroups of non-smoking cotton industry workers who, in comparison to non-smoking office workers, reported more severe intensity of dyspnea (p=0.002) and wheezing (p=0.004). Accordingly, non-smoking office workers were found to have increased predicted FEV<sub>1</sub>% and FEV<sub>1</sub>/FVC values compared to non-smoking cotton industry workers (Table 4).

Significant (p<0.001) negative association was found between FEV<sub>1</sub>/FVC and du-

**Table 2:** Comparison of spirometric results, between two studied groups. Values are either mean (SD) or n (%).

Variable	Cotton industry workers (n=256)	Office workers (n=148)	p value
FEV <sub>1</sub> (L)	3.25 (0.79)	3.37 (0.76)	0.137
FEV <sub>1</sub> (% pred)	91.68 (12.01)	94.36 (9.98)	0.016
FVC (L)	3.98 (0.99)	4.02 (0.91)	0.699
FVC (% pred)	90.6 (11.43)	90.0 (11.43)	0.586
FEV <sub>1</sub> /FVC (%)	81.77 (5.76)	84.20 (5.07)	<0.001
FEV <sub>1</sub> /FVC (% pred)	98.02 (6.80)	104.51 (6.47)	<0.001
FEV <sub>1</sub> <80% pred	41 (16%)	4 (2.7%)	<0.001
FEV <sub>1</sub> /FVC <70%	11 (4.3%)	0 (0%)	0.006

ration of employment in cotton industry, pack years of smoking, and age. FEV<sub>1</sub>/FVC was found to be highly correlated to the workplace (p<0.001), but not with gender (p=0.148). Multiple linear regression analysis revealed the following equation:

$$FEV_1/FVC (\%) = 84.345 - 0.127DoE - 0.074PYS - 2.52TCG \quad (Eq 1)$$

Where *DoE* is duration of employment (yrs), *PYS* is smoking use (pack-yrs), *TCG* is '1' for the target group and '0' for the comparison group. The analysis in the homogeneous exposure group of cotton industry workers (n=256), resulted in the following equation:

$$FEV_1/FVC (\%) = 85.05 - 0.16DoE - 0.097PYS \quad (Eq 2)$$

For those working in ginning mills (n=44), the predicted FEV<sub>1</sub>% was found to be 86.36% (SD 12.64%), that is significantly lower (p=0.022) compared to workers of other cotton industry sectors (n=212) who had a mean value of 92.23% (SD 11.84%).

## Discussion

In this study, cotton industry workers reported a higher prevalence of respiratory symptoms than office workers. We found that the working environment played a key role in the severity of respiratory symptoms reported by the participants—cotton workers had a significantly higher intensity of dyspnea and wheezing compared to a group of office workers. Chronic exposure to cotton dust is related to both work specific and non-specific respiratory symptoms.<sup>7-9</sup> Results of our survey were in line with previously published studies that reported high rates of dyspnea and chest tightness among cotton industry workers.<sup>12,13</sup> The exposed workers had more respiratory symptoms such as chronic cough, phlegm, chest tightness, and dyspnea. The prevalence of symptoms

**Table 3:** Prevalence of respiratory symptoms among cotton and office workers

Variable	Cotton industry workers, n (%) (n=256)	Office workers, n (%) (n=148)	p value
Chronic cough	23 (9.0)	11 (7.4)	0.421
Chronic sputum production	22 (8.6)	8 (5.4)	0.198
Chronic dyspnea	28 (10.9)	5 (3.4)	0.005
Chronic wheezing	15 (5.9)	1 (0.7)	0.014
MRC			
0	226 (88.3)	144 (97.3)	0.016
1	25 (9.8)	3 (2.0)	
2	3 (1.2)	1 (0.7)	
3	2 (0.8)	0 (0.0)	

in the current study was comparable to the findings of Nafees, *et al*,<sup>10</sup> who found that 7.5% and 12.9% of cotton workers had chronic cough and chronic phlegm, respectively. Nevertheless, they found a significantly higher prevalence of wheeze and shortness of breath (22.3%) compared to ours. The prevalence of respiratory symptoms in our study was also lower than that reported by Hinson, *et al*,<sup>11</sup> reflecting possible differences between production units

**Table 4:** Self-reported symptoms, and lung function parameters among non-smokers. Values are either n (%) or mean (SD).

Variable	Cotton industry workers (n=132)	Office workers (n =82)	p value
Chronic dyspnea	15 (11.4%)	1 (1%)	0.004
Chronic wheezing	15 (11.4%)	1 (1%)	0.002
FEV <sub>1</sub> (L)	3.24 (0.79)	3.51 (0.78)	0.013
FEV <sub>1</sub> (% pred)	93.16 (11.35)	98.26 (10.19)	0.004
FVC (L)	3.95 (0.99)	4.18 (0.94)	0.095
FVC (% pred)	91.88 (11.06)	92.63 (9.77)	0.614
FEV <sub>1</sub> /FVC (%)	82.54 (5.40)	84.64 (5.36)	0.002



in different countries. We also reported a higher prevalence of abnormal lung function parameters among cotton workers in comparison to controls that was in keeping with previous studies that reported a variety of respiratory disorders such as byssinosis and asthma.<sup>11-15</sup> We found that cotton industry workers had lower predicted FEV<sub>1</sub>% and FEV<sub>1</sub>/FVC values compared to a comparison group of office workers. These results were suggestive of impaired airway function and might be related to occupational exposure to cotton dust. We also found that workers in cotton industry had a higher risk of developing obstructive pulmonary diseases, since the number of workers with FEV<sub>1</sub>% <80% and FEV<sub>1</sub>/FVC <70% was significantly higher than that in the comparison group. Therefore, it seems that long-term exposure to agents present in textile industries leads to obstructive lung disease that has features of both asthma and chronic obstructive pulmonary disease.<sup>16-19</sup>

The duration of employment in the cotton industry was significantly correlated to FEV<sub>1</sub>/FVC, an indicator of obstructive respiratory disease. It has been shown that long-term exposure to cotton dust is associated with obstructive pulmonary disease that progresses with duration of exposure.<sup>20,21</sup> Several studies suggested that the

negative impact of exposure to cotton dust on pulmonary function depends on the duration of exposure, among other factors including age and smoking.<sup>22,23</sup> Equation 1 shows a drop of 0.127% in FEV<sub>1</sub>/FVC, for each extra-year of work in cotton industry factors. Previous studies in loom workers have also identified that FEV<sub>1</sub>/FVC had a significant ( $p < 0.001$ ) negative correlation with exposure time.<sup>24</sup> On the other hand, the fact that FEV<sub>1</sub>, as well as the reported symptoms were not significantly correlated with work duration could be attributed to the fact that similar duration of exposure does not necessarily mean similar total dose of exposure.<sup>25</sup>

The prevalence of respiratory symptoms and decreased spirometry capacities (FEV<sub>1</sub>, FVC, and FEV<sub>1</sub>/FVC) in smokers were expectedly significantly higher than in non-smokers. These results indicated that smoking might enhance the effect of cotton dust exposure on respiratory symptoms and pulmonary diseases.<sup>19,26</sup> We found a high prevalence of smoking (48.4%) among cotton industry workers. This finding was in line with previous studies, which reported a high prevalence of smoking among Greek industrial workers.<sup>27,28</sup> Our findings on smoking could form the base for the development of workplace-based anti-smoking activities. It has been suggested that an effective anti-smoking policy in worksite should not be isolated, but integrated into a broader context of occupational health and safety and health promotion. There is evidence that offering programs to reduce exposures to occupational hazards may stimulate worker's participation in health promotion activities. Such a holistic approach could significantly reduce both occupational exposures and prevalence of smoking among industrial workers.<sup>27</sup>

Cotton ginning was the cotton industry sector with the highest burden of respiratory illnesses compared to spinning, weav-

#### TAKE-HOME MESSAGE

- Exposure to various dust-related hazards in workers in cotton industry is common.
- Workers in cotton industry reported a higher prevalence of respiratory symptoms compared to non-exposed workers. Cotton workers had a significantly higher intensity of dyspnea and wheezing compared to a group of office workers.
- The duration of exposure to cotton industry agents can be used as an independent predictor of the decline observed in FEV<sub>1</sub>/FVC.

ing, and clothes/fabric sectors. The cotton dust visually observed in that sector was significantly more at least as perceived by both the workers and the researchers. Further analysis among the homogeneous exposure group of 256 cotton industry workers indicated that the impact of duration of employment was stronger than that of smoking (Eq 2). The  $FEV_1/FVC$  was found to be highly correlated with the workplace, duration of employment in cotton industry, and smoking use (Eq 1). Workplace health surveillance and periodical medical examination of cotton industry workers could help to early identification of new cases with obstructive pulmonary disorders. Self-reported symptom questionnaires and spirometry are commonly used in surveillance programs, even though questions have been raised regarding their validity and reliability.<sup>29,30</sup>

Our study had several limitations that need to be taken into account prior to the interpretation of the results. The cross-sectional nature of the study could only provide evidence for possible association and not for causation. In addition, our sample cannot be considered an entirely representative sample of worker's population of cotton industry in Greece. The present study was also limited by the use of self-reported data (questionnaire on respiratory symptoms) and some information bias might thus have occurred. Finally, we could not elucidate which of the multiple agents contained in cotton dust mostly affected respiratory symptoms as well as the lung function results.

In conclusion, we found that working in cotton industry was associated with a higher prevalence of respiratory symptoms compared to office workers. The symptoms were co-existed with spirometry results suggestive of airflow obstruction. The duration of exposure to cotton industry agents can be used as an independent predictor of the decline observed in  $FEV_1/$

FVC. The association between duration of employment in the cotton industry and its impact on decline in lung capacities was independent from and stronger than that of smoking. Workers in cotton ginning mills were the most heavily impacted people, both in terms of spirometric indices and reported symptoms.

**Conflicts of Interest:** None declared.

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