Original Article
Pulmonary function, respiratory symptoms and associated factors among cotton-ginning workers at Gondar city, Northwest Ethiopia: a comparative cross-sectional study

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Abstract: Background: Cotton dust is one of the risk factors for occupational respiratory diseases, a condition characterized by reduced pulmonary function and overwhelming respiratory symptoms. Therefore, this study aimed to determine pulmonary function parameters, respiratory symptoms, and associated factors among cotton-ginning workers at Gondar city, northwest Ethiopia. Methods: A comparative cross-sectional study was conducted on 166 (83 cotton-ginning workers and 83 healthy controls) individuals. Simple random sampling and convenience sampling techniques were used to recruit cotton-ginning workers and controls, respectively. Pulmonary function parameters were measured using Spirometer. Data on respiratory symptoms were collected using the Modified American Thoracic Society questionnaire. We used Chi-square (χ^2) and independent "t" test to compare the outcome variables between the two groups. Binary logistic regression was used to identify the associated factors of respiratory symptoms among cotton-ginning workers. The strength of association was determined using an adjusted odds ratio (AOR) with its 95% confidence interval (CI) and statistical significance was decided at P<0.05. Results: Cotton-ginning workers had reduced FVC, FVC%, FEV1, FEV1/FVC%, PEFR and FEF25-75%) as compared with controls. The prevalence of overall respiratory symptom was 68.6% (95% CI: 57.8, 77.8) among cotton-ginning workers and 19.2% (95% CI: 12, 29.3) among controls. Females (AOR=5.9, 95% CI: 1.19, 29.9), those with primary and secondary education (AOR=7.9, 95% CI: 1.2, 52), working at ginning department (AOR=9.4, 95% CI 1.6, 53) and pressing department (AOR=8.0, 95% CI: 1.3, 48) and not using personal protective equipment (PPE) (AOR=9.1, 95% CI: 1.8, 45.1) had an increased odds of having respiratory symptoms. Conclusion: Reduced pulmonary function parameters and a higher prevalence of respiratory symptoms were observed among cotton-ginning workers than controls. This suggests the need to tailor workplace safety measures to prevent occupational respiratory diseases.

Keywords: Dust, ginning, lung functions, respiratory symptoms, Ethiopia

Introduction

Occupational respiratory diseases are among the major worldwide public health problems accounting for 30% of all registered work-related diseases and 10-20% of respiratory-related deaths [1-3]. Cotton ginning factory is one of the dust releasing industries that is associated with a reduced pulmonary function tests (FVC, FEV_1, and FEV_1/FVC ratio) [4-6] and an increased prevalence of respiratory symptoms mainly dry cough, phlegm, chest tightness, chest wheezing, and breathlessness [6]. Cotton dust contains a complex mixture of ground-up plant matter, cotton fiber, bacterial, fungi soil, or pesticides; all of which can affect the respiratory tract [2, 4, 7, 8] to cause reduced oxygen retaining capacity through the production of pro-inflammatory mediators [9, 10].

Cotton dust related respiratory disorders start to drop in developed countries while the problem is quite neglected in developing countries [3]. According to studies done in Egypt, India,

and Pakistan, workers in cotton ginning factories have a reduced in pulmonary function test measurements [5, 11, 12]. Moreover, working in cotton ginning factories is associated with an increased prevalence of respiratory symptoms [11, 13] which can vary among different sections of the factories [13, 14]. Educational status [15, 16], duration of employment [16], cigarette smoking and sex were significantly associated with respiratory symptoms [4, 9].

Despite the presence of a high amount of cotton dust production that can cause the highest-burden of respiratory illnesses in cotton ginning, compared to spinning, weaving, and clothes/fabric sectors [2, 13, 17], there is a paucity of data concerning pulmonary function parameters and respiratory symptoms among cotton ginning workers in Africa, particularly in Ethiopia. Therefore, this study aimed to determine pulmonary function, respiratory symptoms, and associated factors among cotton ginning workers in Gondar city. Conducting this research will provide information to policymakers to take different ontervention measures in the country.

Methods and materials

Study design, setting, and population

A comparative cross-sectional study was carried out from 15-February-2020 to 15-March-2020 among cotton ginning workers in Gondar city, Northwest Ethiopia. A total of three ginning factories were found in Gondar city employing more than 250 workers. All workers in cleaning, ginning, and pressing departments of cotton ginning factories served in Gondar city and employees in Gondar city that had no exposure to cotton dust, located in the surroundings (estimated to be 500-2000 meters far from cotton ginning factories) were the study population for cotton ginning workers and non-cotton ginning workers, respectively.

Inclusion and exclusion criteria

For exposed group thoe cotton ginning workers who were directly involved in the production unit or cotton processing unit for more than six months were included. Those cotton ginning workers with previous exposure to other occupational dust, such as silica, and coal dust, those who had a history of asthma or chronic obstructive pulmonary disease before joining

the factory, and pregnant women were excluded.

For control group, office workers at Gondar town who were free of cotton dust and age, sex matched individuals were included. Similarly, those who have history of smoking, asthma or COPD were excluded from control group.

Sample size determination and sampling procedure

The sample size for this study was determined using the double population proportion formula. The assumptions considered to calculate the sample size were; $P_1=0.478$ (proportion of respiratory symptoms among exposed group) and $P_2=0.153$ (proportion of respiratory symptoms among unexposed group [7], a 95% CI, 90% power, 1:1 ratio of exposed to an unexposed group, and a 5% non-response rate. Accordingly, the final sample size was 166 (83 to each group).

To recruit participants of the cotton-ginning workers (exposed group), we first randomly selected two cotton ginning factories from the three cotton ginning factories. Next, the desired participants were recruited using simple random sampling technique (lottery method). We used convenience sampling technique to select controls. Sex, age and educational level mached controls with that of cotton-ginning workers was made while recruiting the controls.

Operational definitions

Cleaning: It is the use of various types of cylinder cleaners designed primarily for the removal of dirt and immature seeds, small pieces of leaves, bracts, and other vegetative matter.

Ginning: It is the process of separating cotton fibers from the seed for the conversion of the cotton into a continuous thread.

Pressing: It is the process in which the cleaned and ginned cotton is compressed into bales, which must then be covered to protect them from contamination during transportation and storage. It is the final step in processing cotton in the ginning industry [18].

Data collection instrument and procedures

Lung function measurements were performed with a portable spirometer (GIMASPIR-120 C;

Italia). Percentage-predicted (FEV_1), Forced Vital Capacity (FVC), and their ratio (FEV1/FVC) were recorded in liters. The standardization of spirometry was done using the American Thoracic Society-European Respiratory Society [19]. All spirometric measurements were made in a sitting position after pinching the nose with 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 analyses. Lung function measurements were conducted by a trained physician. Dust concentration was measured using AIRVEDA dust measuring equipment (PM10 and PM2.5). It was placed and operated centrally about 1.5 meters above the floor of the breathing zone within the area to be monitored, away from localized air currents due to fans, blowers, ventilation intakes, or exhausts. A total of six dust samples were collected in the cleaning, ginning, and pressing house over the 8-h day work shift.

A modified version of the validated American Thoracic Society Division of Lung Disease questionnaire (ATS-DLD-78A) was used to collect data regarding respiratory symptoms. It includes questions regarding socio-demographic, past illness, and respiratory symptoms. Each respiratory symptom (cough, phlegm, wheezing, breathlessness, and chest tightness) that lasts for three months among workers determined the presence of each respiratory symptom. Overall respiratory symptom was defined for the presence of at least one respiratory symptom.

Data management and statistical analysis

To assure data quality, first, the spirometer was calibrated. Pretested structured questionnaire was also used to collect sociodemographic and other variables. Then, the collected data were entered into Epi-Data version 3.1 and analyzed by using Stata version-14.0 software. The data were expressed in terms of mean ± standard deviation (SD), frequency, and percentage. Chi-square (χ^2) and independent "t" test were used to compare the prevalence of respiratory symptoms and lung function tests between cotton ginning workers and controls, respectively. Binary logistic regres-

sion analysis was performed to identify candidate variables for the multivariable logistic regression and those variables with *P*-value <0.2 were entered into the final model. In the final model, variables with P<0.05 were considered statistically significant. The strength of association was described using an adjusted odds ratio (AOR) with its 95% CI.

Results

A total of 166 participants (83 cotton-ginning workers and 83 controls) were participated in the study with a response rate of 100%. The mean age of cotton-ginning workers and controls was 33.19 (±7.85) years and 34.90 (±8.18) years, respectively. Regarding the working department of ginning workers, 33 (39.76%) were from the ginning department, 23 (27.71%) from cleaning department. Out of 83 participants of exposed respondents, 43.37% attended secondary education whereas 56 (67.4%) controls attended secondary school and above. The mean height and weight of the cotton-ginning workers were 165.21 cm and 58.3 kg, respectively. Only 16 (19.2%) ginning workers used a mask as PPE. None of the study participants (cotton-ginning workers and controls) were found to be cigarette smokers (**Table 1**). There was no significant difference between the cotton-ginning workers and controls regarding age, sex, marital status, weight, and height. However, between groups, there was a significant difference in monthly salary.

Compared to controls, cotton ginning workers (in all working departments) were exposed to a high level of cotton dust. The highest particulate matter (PM-10 µm) was in the ginning department (820 µg/m³) and the lowest was in the cleaning department (420 mg/m³). Similarly, the PM-2.5 µm was also high in the ginning department (256 mg/m³) and the lowest was in the cleaning department (224 mg/m³) (**Table 2**).

Pulmonary function parameters

An independent sample t-test was used to compare lung function parameters (FVC, FEV_1, FEV_1/FVC%, FEF_{25-75}, and PEFR, both as absolute and percent predicted values) between cotton-ginning workers and controls. The mean values of FVC, FEV_1, $FEV_{1\%}$, FEF_{25-75}, and

Table 1. Comparison of demographic and socioeconomic characteristics between cotton ginning workers and controls, Gondar, Ethiopia, 2020

Variables	Cotton ginning workers N (%)	Non-cotton ginning controls N (%)	*P*-value
Sex			
Male	48 (57.8%)	45 (54.2%)	0.457
Female	35 (42.2%)	38 (45.7%)	
Age (in years)			
21-30	42 (50.6%)	31 (37.3%)	0.876
31-40	27 (32.5%)	32 (38.6%)	
≥40	14 (16.9%)	20 (24.1%)	
Duration of employment			
1-2 years	31 (37.3%)	23 (27.8%)	0.345
3-5 years	29 (35.0%)	30 (36.1%)	
≥6 years	23 (27.7%)	30 (36.1%)	
Marital status			
Married	49 (59.0%)	51 (61.4%)	0.152
Single	28 (33.7%)	31 (37.4%)	
Divorced/widowed	6 (7.2%)	1 (1.2%)	
Salary			
≤56.8 Euro	12 (14.4%)	2 (2.4%)	p≤0.001
56.81-90.9 Euro	39 (46.9%)	15 (18.0%)	
≥90.91 Euro	32 (38.5%)	66 (79.5%)	
Height	165.21 cm±0.08	165.73 cm±0.07	0.681
Weight	58.3 kg	59.39 kg	0.421

Table 2. Mean cotton dust concentration distribution across departments in cotton ginning factory, Gondar, Ethiopia, 2020

Departments	Cotton dust measurement						Overall dust mean
	PM-2.5 mg/m³			PM-10 mg/m³			
	Min	Max	Mean	Min	Max	Mean	Average mean
Cleaning	210	238	224	378	452	420	644 µg/m³
Ginning	252	260	256	750	890	820	1076 µg/m³
Pressing	220	250	235	402	758	580	815 µg/m³

PEFR had a significant reduction among cotton-ginning workers compared to controls. The percentages of the predicted values and the mean difference were highly significant between the two groups (P<0.05) (**Table 3**).

Prevalence of respiratory symptoms

The overall prevalence of respiratory symptom was 68.6% (95% CI: 57.8%, 77.8%) in cotton-ginning workers and 19.2% (95% CI: 12.0%, 29.3%) in controls. The prevalence of cough, phlegm, wheeze, breathlessness, and chest-tightness were 50.6%, 43.3%, 27.7%, 30.1%, and 37.3%, respectively, for cotton-ginning workers. Among the three departments of the

factory, workers in the ginning department had the highest prevalence of respiratory symptoms (47.3%) (**Table 4**).

Factors associated with respiratory symptoms

In the multivariable binary logistic regression sex, working department, educational status, and PPE use were statistically significant with the respiratory symptoms among cotton-ginning workers (P<0.05).

Females had 6 times (AOR=5.9, 95% CI: 1.19, 29.9) higher odds of developing respiratory symptoms compared to males. Ginning workers with primary and secondary education had 8

Table 3. Comparison of observed and percent predicted parameters among cotton ginning and non-cotton ginning controls, Gondar, Ethiopia, 2020 (n=166, each 83)

Variables	Cotton-ginning workers (mean ± SD)	Controls (mean ± SD)	Mean difference 95% CI	P-value
FVC (I)	2.79±0.67	3.13±0.46	-0.34 (-0.5, 0.17)	0.0002
FVC% predicted (I)	62.83+15.68	72.57+12.15	-9.74 (-14, -5.4)	0.0001
FEV_1 (I)	2.56±0.62	3.01±0.43	-0.44 (-0.6, -0.27)	0.0001
FEV1% predicted (I)	72.76+18.7	87.89+13.5	-15.1 (-20.1, -10.1)	0.0001
FEV_1/FVC% (I)	92.2±10.4	96±5.9	-3.7 (-6.3, -1.1)	0.0048
FEV_1/FVC% predicted (I)	114.9+12.9	119.07+9.9	-4.1 (-7.6, -0.57)	0.0230
PEFR (I/s)	4.88±2.05	6.25±1.5	-1.3 (-1.9, -0.80)	0.0001
PEFR% predicted (I/s)	61.81+23.9	79.30+19.7	-17.4 (-24.2, -10)	0.0001
$FEF_{25\%-75\%}$ (I/s)	3.77±1.53	4.82±1.13	-1.05 (-1.4, -63)	0.0001
$FEF_{25\%-75\%}$ pred (I/s)	103.7+40.2	127.39+35.4	-23.61 (-35, -11.9)	0.0001

Table 4. Prevalence of respiratory symptoms among cotton ginning factory workers, Gondar, Ethiopia, 2020

Respiratory symptoms	Cotton-ginning workers		Non cotton-ginning workers		P-value
	N (%)	95% CI	N (%)	95% CI	
Cough	42 (50.6%)	(39.8-61.3)	17 (20.4%)	(13.0, 30.6)	≤0.001
Phlegm	35 (43.3%)	(33-54.3)	13 (15.6%)	(9.2, 25.2)	≤0.001
Wheezing	23 (27.7%)	(19-38.4)	8 (9.6%)	(4.8, 18.2)	≤0.001
Breathlessness	25 (30.1%)	(21.1-40.9)	10 (12%)	(6.5, 21.1)	≤0.001
Chest Tightness	31 (37.3%)	(27.5-48.3)	10 (12%)	(6.55, 21.1)	≤0.001

N=Frequency, CI=confidence interval.

times (AOR=7.9, 95% CI: 1.2, 52) higher odds of developing respiratory symptoms as compared to the ginning workers with a diploma and above educational status. Respondents working in the ginning and pressing departments had 9.4 (AOR=9.4, 95% CI: 1.6, 53) and 8 (AOR=8.0, 95% CI: 1.3, 48) times higher odds of developing respiratory symptoms compared to workers in the cleaning department. Workers who did not use personal protective equipment had 9 times higher odds of developing respiratory symptoms compared to their counterparts (AOR=9.1, 95% CI: 1.8, 45.1) (**Table 5**). Despite significant variations between groups, there was no significant association between salary and respiratory symptoms.

Discussion

Cotton ginning factories are considered as dustiest areas with high amounts of endotoxin and cotton dust level that are associated with pulmonary function abnormalities. Therefore, cotton-ginning workers are at risk of acquiring respiratory illnesses following exposure to cotton dust. Hence, this study was intended to assess pulmonary function and respiratory symptoms, and associated factors among cotton ginning workers.

In this study, both the observed and predicted percentage of pulmonary function parameters (FVC, FEV_1, FEV_1/FVC, PEFR, and $FEF_{25\%-75\%}$) were significantly lower in the cotton-ginning workers than controls. This finding is similar to the studies done on cotton ginning factories in India [4, 5, 20] Pakistan [21], Egypt [11], Nigeria [22], and northern Benin [14] in that exposure to cotton dust is associated with a significant reduction in FVC, FEV_1, PEFR, $FEV_{1\%}$, FVC%, FEV/FVC%, and PEFR%. This is probably due to the accumulation of cotton dust particles in the airways and the presence of endotoxin in the cotton which are responsible for inflammation of the airways that impairs breathing [23].

In the present study, the overall prevalence of respiratory symptoms was higher among par-

Table 5. Associated factors of overall respirstory symptomsa obtained from multivariable binary logistic regression analysis among cotton-ginning factory workers, Gondar, Ethiopia, 2020

Variables		Respiratory symptoms		OR (95% CI)	
		Yes N (%)	No N (%)	COR	AOR
Sex	Male	30 (62.5%)	18 (37.5%)	1.00	1.00
	Female	27 (77.1%)	8 (22.8%)	2.0 (0.75, 5.4)	5.9 (1.19, 29.93)*
Age	21-30 years	25 (59.5%)	17 (40.7%)	0.6 (0.22, 1.7)	0.3 (0.08, 1.6)
	31-40 years	19 (70.3%)	8 (2.9%)	1.00	1.00
	≥41 years	13 (92.8%)	1 (7.14%)	5.4 (0.6, 49)	0.12 (0.011, 1.29)
Working section	Cleaning	11 (47.8%)	12 (52.1%)	1.00	1.00
	Ginning	27 (81.8%)	6 (18.1%)	4.9 (1.47, 16.3)	9.4 (1.6, 53)*
	Pressing	19 (70.3%)	8 (29.6%)	2.5 (0.81, 8.2)	8.0 (1.3, 48)*
Educational status	No formal education	9 (81.8%)	2 (18.8)	10.5 (1.36, 81)	0.83 (0.11, 6.2)
	Primary and secondary school	45 (72.5%)	17 (27.4%)	6.17 (1.0, 26)	7.9 (1.2, 52)*
	Diploma and above	3 (30%)	7 (70%)	1.00	1.00
PPE use	Yes	6 (37.5%)	10 (62.5%)	1.00	1.00
	No	51 (76.1%)	16 (23.8%)	5.3 (1.6, 16)	9.1 (1.8, 45.1)*

PPE=Personal protective equipment, COR=Crude odds ratio, AOR=Adjusted odds ratio, *Significant at 95% significance level.

ticipants exposed to cotton dust (68.6%) than controls (19.2%). This is in agreement with the study done in Nigeria, Kano textile workers [22], and Egypt [11]. This might be to the fact that in the current study of cotton-ginning workers, there is exposure to cotton dust that results in respiratory symptoms [6, 11, 16]. However, the overall prevalence of respiratory symptoms among cotton ginning workers in the current study is higher than the study done in Bangladesh [24] and Ethiopia [7]. This might be due to the current study was done only in ginning factories that have a high amount of cotton dust to cause respiratory problems compared to other departments. Conversely, the above two studies were conducted in all departments of textile factory including weaving and spinning with less amount of cotton dust compared to ginning factories.

In our study, sex, working department, education level, and PPE use were associated with respiratory symptoms. Female respondents had higher odds of developing respiratory symptoms compared to males. This finding is in contrast to studies done in China [25], and Maharashtra, India [5]. The possible reason for the high prevalence of respiratory symptoms in females in this study might be due to the presence of several other risk factors, such as indoor air pollution due to the use of cheap fuel that may predispose them to have a higher chance of respiratory symptoms compared to males.

The working department was another factor significantly associated with respiratory symptoms. Workers in the ginning department had higher odds of respiratory symptoms compared to cleaning. It is known that dust concentrations are higher in initial processes and because workers in higher cotton dust exposure work environments such as ginning and pressing are more likely to develop respiratory symptoms than those workers within office work respondents whereby there is less cotton dust exposure [5, 23]. This justification is supported by studies done in Greece in 2017 [6, 26]. Moreover, the study done in Ahmedabad, India showed that the concentration of cotton dust with a particle size of 2.5 $\mu g/m^3$ was higher in the ginning department which might increase the risk of developing respiratory symptoms [23].

In this study, those who attained primary and secondary school had higher odds of developing respiratory symptoms than employees with a diploma and above. This study is in agreement with the study done in Pakistan [15, 27]. Less-educated workers usually lack information about the risks of occupation-related diseases in general and about cotton dust in particular. In addition, half of the less-educated respondents had service years of more than 3 years, which could be accustomed to the work environment and developed false consciousness of safety that might drive them not to comply with safety precautions like proper use of PPE.

The use of PPE was also significantly associated with respiratory symptoms. These findings are in line with the study done in Thailand, Bangkok, in which workers who used PPE had reduced respiratory symptoms [28]. This could be due to the fact that wearing PPE prevents workers from inspiring dust particles in the working environment.

Limitations

Due to the cross-sectional nature of the study, it is impossible to establish a causal association between cotton dust exposure and impaired lung function and respiratory symptoms. In addition, there might be recall bias and social desirability bias. The American Thoracic society tool used is a screening tool that cannot allow making a medical diagnosis of respiratory diseases. The lack of collecting data on housing conditions was also another potential limitation.

Conclusion

Workers in cotton ginning factories had reduced lung function parameters (FVC, FEV_1, FEV1/FVC, PEFR, and $FEF_{25\%-75\%}$) and a higher prevalence of respiratory symptoms compared to controls. Sex, working department, use of PPE and education level were associated with respiratory symptoms. Thus, reducing exposure to dust and providing adequate personal protective equipment for workers are needed to reduce respiratory problems and impaired lung function-tests.

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Disclosure of conflict of interest

None.

Abbreviations

FEF25-75%, Forced Expiratory Flow at 25%-75% of pulmonary volume; FEV1, Forced Expiratory Volume at first second; FVC, Forced Vital Capacity; PEFR, Peak Expiratory Flow Rate; PPE, Personal Protective equipment.

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