BYSSINOSIS: RESPIRATORY PROBLEMS AMONG COTTON TEXTILE MILL WORKERS IN ETHIOPIA

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INTRODUCTION

Although occupational lung disorder caused by inhalation of cotton dust is a continuing problem and byssinosis is now known to occur worldwide, cotton production and consumption has expanded rapidly in developing countries. The People's Democratic Republic of Ethiopia being one of the cotton producers and consumers countries in Africa, started expanding its textile industries since the last decade and the number of its workers in cotton processing continues to grow annually.

Lots of studies in cotton mills were done and reported from many developed nations and also few reports regarding respiratory problems have been documented from developing countries like Egypt,[1] Sudan,[2] Tanzania,[3] and Hong Kong,[4] but there is no article published concerning the problems caused by cotton dust in Ethiopia. Thus, this paper represents the first epidemiological study of the textile industry in Ethiopia using diagnostic criterion similar to those which are applied in developed countries, such as the United States of America and Great Britain.

A few studies of cotton textile workers have looked into the prevalence of respiratory symptoms and lung function compared with those of control subjects.[5,6,7,8] There is also a limited number of studies that have reviewed lung function in cotton textile workers with and without byssinosis or bronchitis.[9,10,11] This study investigated the prevalence of byssinosis and other respiratory problems among workers exposed to cotton dust in a textile mill in Ethiopia and also attempted to explore determinants by considering workers exposed to cotton dust in the textile mill with respiratory tract diseases as case study group and without respiratory tract disease as control group.

This cotton textile mill was established in the early 1960s and a daily eight hourly system is operating continously for the whole week, while intermittently providing a "day-off" for each worker to rest. In spite of the attempt to retrofit current ventilation systems in the early 1980s, plant officials stated that the dusty environment remained unchanged since the early 1960s.[12]

MATERIAL AND METHODS

Population

This study included a group of randomly selected 595 workers (322 male and 273 female) representing 40.5% of workers involved in dusty operations in the blowing, carding, drawing, simplex, ringframe, preparatory and weaving sections of a cotton textile mill in Bahir Dar, Ethiopia.

Environmental Assessment

The concentration of airborne dust in the breathing zone was determined with the casella personal dust sampler and the sampling rate was set to 0.2 l/min. The concentration of airborne dust in the general environment was concurrently monitored with an Anderson dust sampler fitted with a vertical elutriator (General Metal Works Inc.) that was set up at a height of 1.5m at selected positions and samples were drawn at a rate of 7.4 l/min. Multiple area samples were taken and the duration of sampling ranged between 8-10 hours (mean 8.7 hours). All samples were collected on What man glass fibre GF/A with 3.7 cm diameter and weighing was done on a calibrated analytical balance before and after sample collection after equilibrating filters in the laboratory for 24 hours.

Interviews and Physical Examination

A modified version of the British Medical Research Council Questionnaire was filled out and each worker was fully examined with emphasis being laid on signs and symptoms suggestive of respiratory diseases. All workers were blindly interviewed and examined by one trained physician. The stages of byssinosis were defined according to the clinical grades suggested by Schilling et al.[13] Subjects were also diagnosed as having other respiratory diseases based on previously stated criteria.[14,15,16] Subjects who gave confirmed past history of respiratory diseases were also considered in this study.

Pulmonary Function Test

Subjects' forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) were measured under the direction of a technician using a multipurpose spirometer.

Function testings were carried out on each worker on the first day of the shift after at least one day absence from work and repeated at the end of the same shift. Five expiratory efforts were recorded and the mean of the two highest values was used to estimate the FEV_1 and FVC. All volumes were adjusted to body temperature and pressure saturated with water vapour (BTPS). The preshift FEV_1 values were compared with the expected normal values of Cherniack and Rater.[17]

For all statistical tests, P less than 0.05 was considered significant.

RESULTS

Population

All the 595 workers in the study voluntarily underwent interview, physical examination and pulmonary function testing. Non-reproducible function tests of 32 subjects were excluded only from pulmonary function test analysis. There were only 14 smokers and 4 ex-smokers, all male. Over 95% of the cotton workers had not changed jobs or their sections during the course of their employment.

Environmental Assessment

The concetrations of airborne cotton dust are shown in Table I. The highest concentration of cotton dust was recorded in the blowing and carding sections, whereas the lowest was recorded in the weaving and preparatory sections. The amount of dust generated in the blowing and carding operations was high and more than two fold compared to other operations ($P<0.005$). The mean dust concentration and the mean time-weighted dust concentration were much higher ($P<0.001$) in the case study group than in the control group.

Respiratory Conditions

The prevalence of byssinosis and other respiratory tract diseases is summarized in Table II and Figure 1. The prevalences of byssinosis, chronic bronchitis and bronchial asthma were very high ($P<0.001$) among blowers and carders in comparison to those in other sections. The overall prevalence of hay fever (28.3%) was the highest of all the respiratory problems in the textile mill. Generally, the prevalence of byssinosis, chronic bronchitis and bronchial asthma showed a significant increase with the duration of exposure to cotton dust in the textile mill (Table III). No significant difference was observed in the prevalence of byssinosis between smoking and non-smoking workers, otherwise, the effect of smoking on the prevalence of chronic bronchitis was significant (Table IV). In general, 48.1% of the study population had one or more respiratory tract problems while the remaining 51.9% had neither symptoms and signs nor gave past histories of respiratory tract diseases.

We regrouped the study population in two strata based on the frequency distribution of the time-weighted elutriated dust concentration as those with a high and low cumulative dust exposure and cross tabulated, assuming the present dust levels were more or less similar to the past ones.

The estimated relative risks of developing byssinosis and other respiratory problems in high cumulative cotton dust exposure were statistically significant when compared to low cumulative cotton dust exposure (Table V). Also the estimated relative risk of manifesting symptoms of respiratory impairment was significant in those exposed to high cumulative cotton dust and developed respiratory tract problems when compared with those exposed to low cumulative cotton dust (Table VI).

Pulmonary Function Test Analysis

A statistically significant ($P<0.001$) across-shift decrements in FEV_1 and FVC and also a decrease in the percentage predicted FEV_1 were noted in the case study group when compared with the control group. There was a significant reduction in FEV_1 ($P<0.001$) at the end of the shift, more than 10% and/or 20% among byssinotics when compared with the controls (Figure 2). Also a significant increase in percentage reduction in FEV_1 was noted with an increase in byssinoiss grade. The chronic changes in FEV_1 among exposed workers were further analysed according to Bouhuys et al.[18] While 24% of byssinotics developed FEV_1 moderate to severe chronic changes ($P<0.001$), only 1% of the non-respiratory tract disease group (controls) showed similar changes (Table VII).

Generally, the regression analysis results shown in Tables VIII and IX indicate statistically signficant dose-response relationship between respiratory problems and pulmonary function test results at one hand and current, cumulative and length of exposure to cotton dust at the other.

DISCUSSION

The results of our study showed that the concentrations of airborne cotton dust in the different sections of the surveyed textile mill were very high, with concentrations greatly in excess (nearly 4 to 17 tons) of $0.2 mg/m^3$ of dust.[19] This was in accordance with reports on other cotton mills.[2,6,20] Also the dust collected at the early stage of yarn production was very high and this was similar to those reported by others.[2,21,22]

The high prevalence of byssinosis in the blowing and carding processes is similar to those reported by other investigators.[2,23,24] The high prevalence of byssinosis in drawing, simplex and ringframe spinners may be due to the fact that the level of cotton dust was still high in these sections.

Inspite of the controversy surrounding the relationship between the prevalence of byssinosis and the duration of exposure, our study showed a significant increase in the prevalence of byssinosis with duration of exposure. The same relationship had also been observed in Sudan and Egypt.[2,20,21] The progression in the stages of byssinosis in relation to the duration of exposure observed in our finding support previously reported conclusions that the different grades of byssinosis succeed each other in diseased subjects.[2,20,21] Our results also showed that there was a significant association between the prevalence of byssinosis and time-weighted dust concentration. This is in agreement with Fox et al.[25] Our results showed that smoking had no significant relationship with the prevalence of byssinosis, probably because of the small number of smokers in our study. Hence due to this small number, there may be a risk of a type II error.

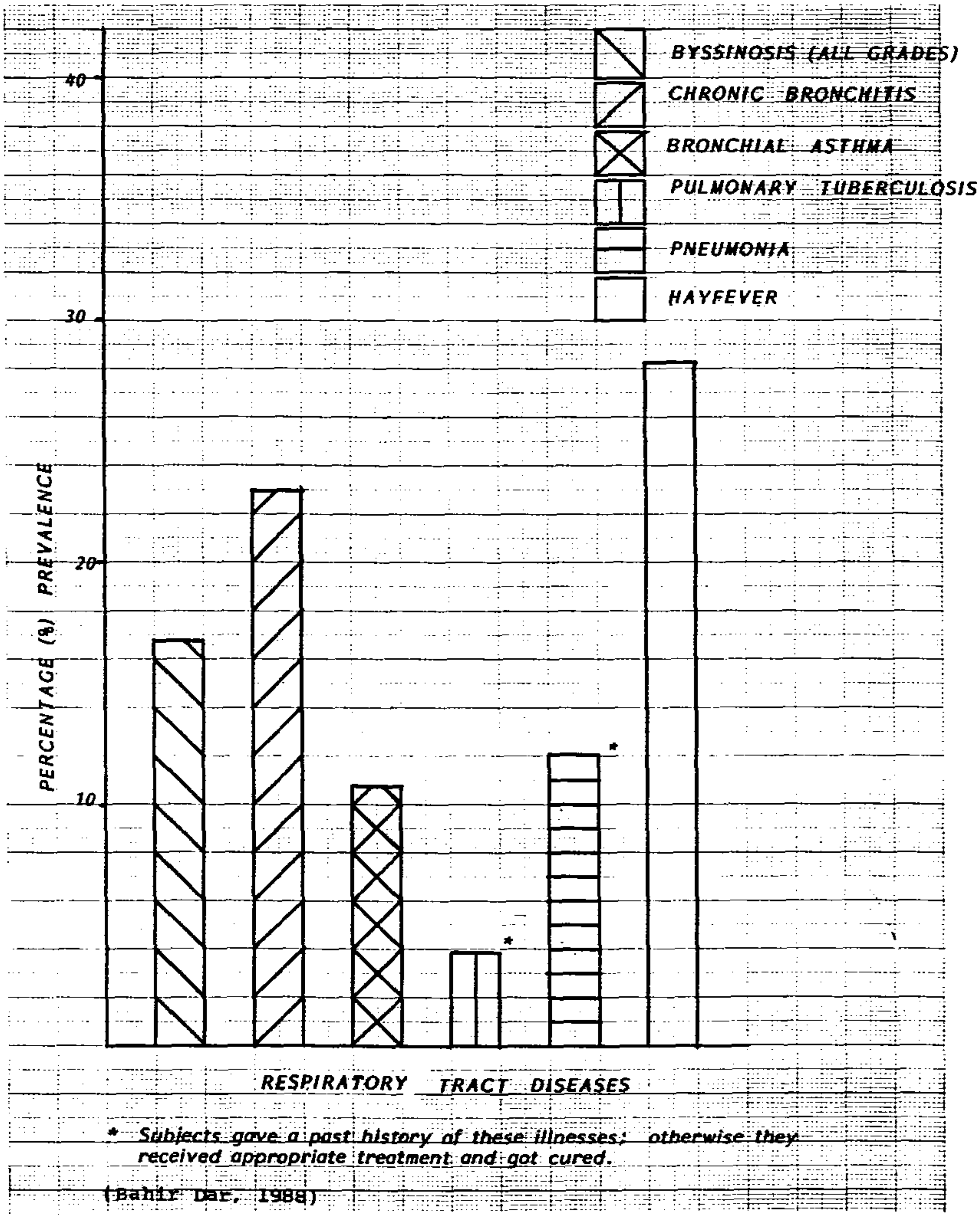

Figure 1. Prevalence of respiratory tract diseases among exposed workers.

Table I
The Concentration of Airborne Cotton Dust in Study Sections by Area Sampling and Personal Sampling (Mean±SD)

Section	Number of Samples	Area Sampling "Inhalable" Dust mg/m^3	Personal Sampling "Respirable" Dust mg/m^3
Blowing (1)	14	3.52 ± 0.98	3.83 ± 1.06
Carding (2)	18	3.21 ± 1.09	3.58 ± 1.07
Drawing (3)	11	1.62 ± 0.44	1.93 ± 0.23
Simplex (4)	11	1.29 ± 0.32	1.72 ± 0.26
Ringframe (5)	21	1.19 ± 0.49	1.57 ± 0.55
Preparatory (6)	12	0.92 ± 0.23	1.21 ± 0.33
Weaving (7)	25	0.86 ± 0.35	1.03 ± 0.37

Level of Significance		
	IV_s2 $P>0.05$	IV_s2 $P>0.05$
	$IV_s3 - 7P<0.0005$	$IV_s3 - 7P<0.0005$
	$2V_s3 - 7P<0.005$	$2V_s3 - 7P<0.0005$

(Bahir Dar, 1988)

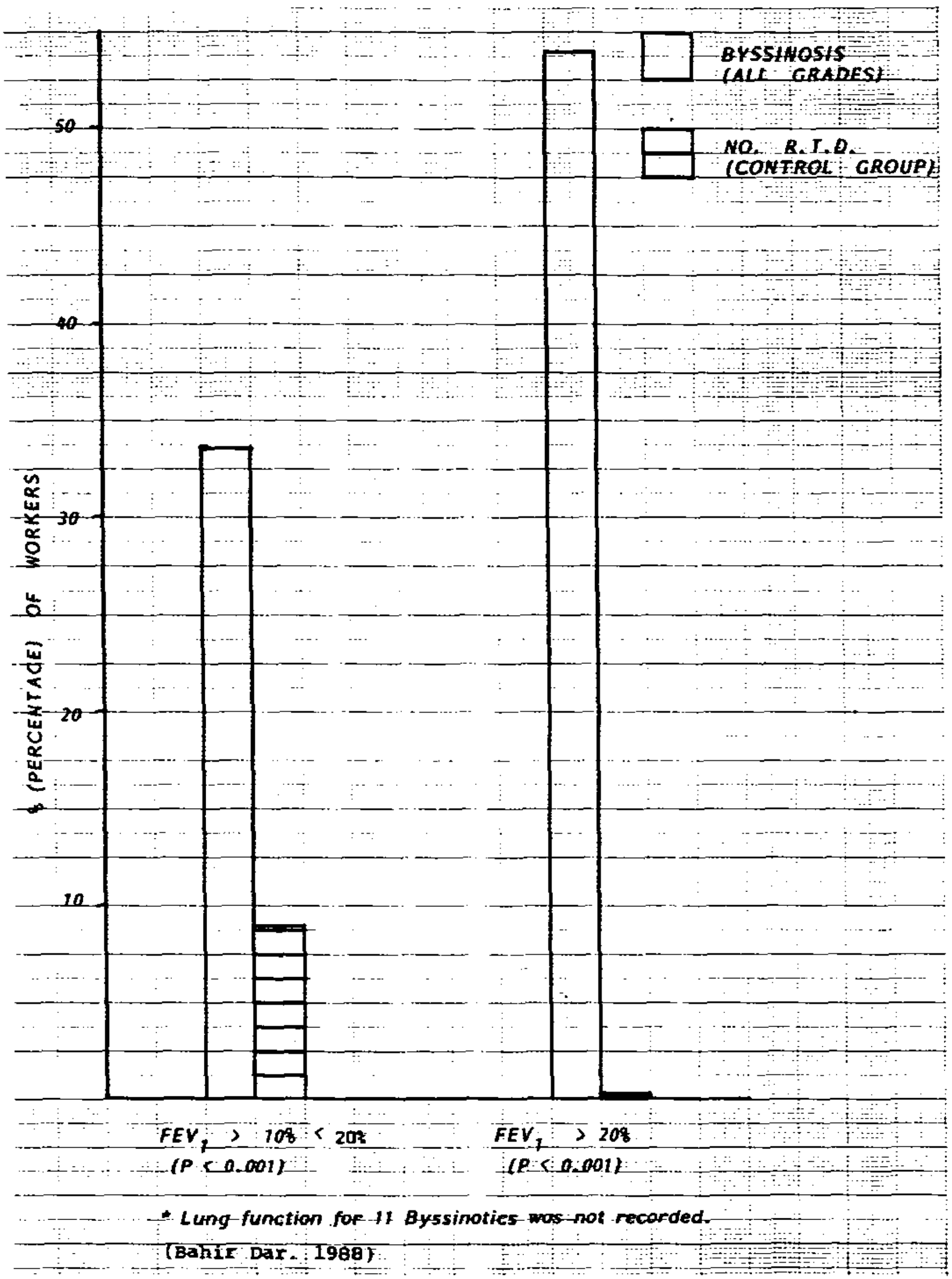

Figure 2. Percent reduction in FEV_1 in examined workers during the first working day after absence from work.*

Table II
The Prevalence of Respiratory Diseases Among Exposed Workers
Mean Age and Duration of Exposure

SECTION	Number Examined	Age (Years) Mean ± SD	Duration of Exposure (Months) MEAN ± SD	BYSSINOSIS NO. (%)				Chronic Bronchitis No. (%)	Bronchial Asthma No. (%)
				G½	GI	GII	Total		
Blowing(1)	44	41.3 ± 7.3	201.9 ± 87.2	3(7)	7(15.9)	9(20.5)	19(43.2)*	21(47.7)*	9(20.5)*
Carding (2)	40	41.5 ± 6.9	200.7 ± 74.8	-	2(5)	13(32.5)	15(37.5)*	18(45)*	5(12.5)
Drawing (3)	25	39.9 ± 6.6	239.6 ± 68.5	3(12)	1(4)	2(8)	6(24)	8(32)	3(12)
Simplex (4)	42	40 ± 6.8	235.3 ± 69.4	3(7)	3(7.1)	4(9.5)	10(23.8)	10(23.8)	3(7.1)
Ringframe(5)	174	37.5 ± 6.5	233.1 ±73.2	12(6.9)	9(5.2)	9(5.2)	30(17.2)	32(20.7)	17(9.8)
Preparatory(6)	128	37.1 ± 5.8	222.9 ±71.5	10(8)	-	4(3.1)	14(10.9)	23(18.0)	15(11.7)
Weaving (7)	142	39 ± 4.6	238.7 ± 67	3(2.1)	2(1.4)	1(0.7)	6(4.2)	25(17.6)	12(8.5)
TOTAL	595	38 ± 6.9	218.3 ± 79.5	34(5.7)	24(4)	42(7.1)	100(16.8)	137(23)	65(10.8)

* P< 0.001
(Bahir Dar, 1988

Table III
Duration of Exposure and the Prevalence of Respiratory Diseases

Duration of Exposure (Years)	Number Examined	BYSSINOSIS NO (%)				Chronci Bronchitis No. (%)	Bronchial Asthma No. (%)
		G½	GI	GII	TOTAL		
< 10 Years	105	2 (1.9)	4(3.8)	-	6(5.7)	17(16.2)	2 (1.9)
10 - 20 Years	208	11 (5.3)	6(2.9)	8 (3.8)	25(12)	43(20.7)	12 (5.8)
> 20 Years	282	21(7.4)	14 (5)	34(12.1)	69(24.5)	77(27.3)	50(17.7)
TOTAL	595	34(5.7)	24(4)	42(7.1)	100(16.8)	137 (23)	64(10.8)
					P<0.001	P< 0.05	P< 0.001

Table IV
The Effect of Smoking on the Prevalence of Byssinosis

GROUP	NUMBER EXAMINED	DURATION EXPOSURE (YEARS) (MEAN ± SD)+	BYSSINOSIS NO. (%) GI/2	GI	GII	TOTAL	CHRONIC BRONCHITIS No. (%)	BRONCHIAL ASTHMA NO. (%)
Smokers	14	17.1 ± 8.2	1 (7.1)	1(7.1)	1(7.1)	3(21.4)*	9(64.3)**	-
Non or Ex-smokers	581	18.2 ± 6.6	33(5.7)	23 (4)	41 (7)	97(16.7)	128 (22)	64 (11)
		+N.S.(P> 0.05)				* N.S.	** P<0.001	

(Bahir Dar, 1988)

Table V
Comparison of Cases (Byssinosis and Other Respiratory Tract Diseases Groups) with Control (No Respiratory Tract Disease Group) Using Time Weighted Dust Concentration

GROUP	High Time Weighted Dust Concentration (366.72-1182.72) (mg months/m³) NO.	%	Low Time Weighted Dust Concentration (183.36 -206.4) (mg months/m³) NO.	%	X^2(1d.f.)	P-Value	Odds Ratio	95% Confidence Interval (C.I.)
Control								
. No R.T.D	78	(38.8)	123	(61.2)				
Cases								
. All R.T.D	122	(63.2)	71	(36.8)	23.46	P<0.001	2.71	(2.48, 2.94)
. Byssinosis	69	(93.2)	5	(6.8)	64.41	P<0.001	21.76	(8.41, 56.26)
. Chronic Bronchitis	67	(69.8)	29	(30.2)	24.96	P<0.001	3.64	(2.16, 6.11)
. Bronchiol Asthma	29	(78.4)	8	(21.6)	19.79	P<0.001	5.72	(2.48, 13.07)
. Plumonary Tuberculosis	12	(75)	4	(25)	7.99	P<0.01	4.73	(1.46, 15.18)
. Pneumonia	32	(61.5)	20	(38.5)	8.68	P<0.01	2.52	(1.34, 4.71)
. Hay Fever	67	(61.5)	42	(38.5)	14.59	P<0.001	2.52	(1.55, 4.06)

(Bahir Dar, 1988)

Although previous investigators[7,25] found that the prevalence of chronic bronchitis is not related to dust concentrations, the significant relationship observed in our study is in agreement with those of El Karim[2] and Merchant et al.[26] Although cigarette smoking is the single most important etiologic factor of chronic bronchitis, occupational and environmental exposures are now receiving more attention as also supported by our finding.

Our finding also showed that bronchial asthma was high among the blowers and had a significant relationship with the cumulative cotton dust exposure. A majority of the asthmatics developed the problem after they had worked for several years in this textile mill. Even though a majority of the asthmatics gave negative family histories of allergy, 34.4% had had intermittent symptoms of rhinitis which was mostly seasonal.

Our finding showed that there was no significant relationship between hay fever and current dust exposure but the relationship with longevity in the cotton textile mill and cumulative cotton dust exposure was significant. This finding probably might be due to the reason that an allergic reaction does not occur on first exposure. The latent interval during which sensitization occurs varies from a few weeks to many years. When hay fever, for that matter even asthma, first develops some years after an employee entered an industry, it is easy to understand that an occupational origin may be completely overlooked. In our study a majority of hay fever cases developed the symptom complex after many years of longevity in the textile mill.

Even though there is some evidence that byssinosis is not more prevalent among atopic than non-atopic workers,[27] our finding revealed that the majority of byssinotics (55%) had clear-cut characteristic symptom complex of hay fever (allergic rhinitis). Added to this, the prevalence of hay fever was very high in our study population. In agreement to this and as described by Jones et al,[28] atopy might be an important risk factor in the development of byssinosis and indicates the importance of identifying atopic workers.

Our study demonstrated that byssinotics had significantly greater acute decrements in FEV_1 throughout a workshift than those without respiratory tract diseases, supporting the findings of earlier investigators.[9,29,30] The cotton exposed workers with byssinosis had also a significantly lower percent-predicted FEV_1 than those in the group without respiratory tract desease (control), being in agreement with previous investigators.[2,8,9,31,32,33]

In conclusion, our findings suggest that there may be high estimated risk of developing respiratory diseases and impairment as well as leading workers to absence from work due to illness in high time-weighted dust concentration than in low time-weighted dust concentration signifying the extent of the occupational health hazard that calls for due consideration by all those concerned. Also an immunological dysfunction such as atopy, may be a risk factor in the development of cotton dust induced respiratory disease. Thus keeping in mind cotton dust has diverse content as described by many investigators, the extent of association between exposure to cotton dust and hay fever and also the extent of development of byssinosis and other respiratory problems among atopic and non-atopic workers should be investigated and analysed in depth.

Table VI

Comparison of Symptoms of Respiratory Impairment and Period of Absence from Work Due to Sickness in Those Cases with High and Low Time Weighted Dust Concentration with "No Respiratory Tract Disease" Group as Control

GROUP	High Time Weighted Dust Concentration (366.72 - 1182.72) (mg months./ m^3)		Low Time Weighted Dust Concentration (183.36 - 206.4) (mg months/m^3)		X^2(1 d.f.)	P-Value	ODDS Ratio	95% Confidence Interval (C.I.)
	No.	(%)	No.	(%)				
Control								
÷ No R.T.D	78	(38.8)	123	(61.2)				
Cases								
. Sob Hill*	112	(70)	48	(30)	34.77	p<0.001	3.68	(2.36, 5.7)
. Sob Level **	81	(80.2)	20	(19.8)	46.18	p<0.001	6.39	(3.6, 11.25)
. Sob Pace ***	29	(87.9)	4	(12.1)	27. 5	p<0.001	11.43	(6.62, 19.89)
. Sick Week	64	(71.9)	25	(28.1)	27.05	p<0.001	4.04	(2.36, 6.96)
. More Illness	32	(69.6)	14	(30.4)	13.77	p<0.001	3. 6	(1.8, 7.17)

(bahir Dar, 1988)

* Shortness of breath while walking up a slight hill
** Shortness of breath while walking on a level ground with persons of the same age
*** Shortness of breath even when walking at own pace.

Table VII
Chronic Changes in FEV_1 among Exposed Workers

Byssinosis	Number Examined	FEV_1 CHRONIC CHANGES *					
		No. Change > 80% of Predicted Value		Moderate 60-80% of Predited Value		Severe < 60% of Predicted Value.	
		No.	%	No.	%	No.	%
No. R.T.D Controls	309(51.93)	210	67.96	96	31.07	3	.97
Byssinosis							
Grade ½	34(5.71)	20	58.82	13	38.24	1	2.94
Grade 1	24(4.03)	11	45.83	8	33.33	5	20.83
Grade II	42(7.06)	9	21.43	15	35.71	18	42.86
All Grades	100(16.81)	40	40	36	36	24	24**
Total	595(100)	376	63.19	191	32.1	28	4.71

Lung function was not recorded for 32 subjects.

* Graded according to Bouhuys et al. (1970)

** $P < 0.001$

(Bahir Dar, 1988)

Table VIII

Regression Coefficients for Time Weighted Cotton Dust Concentration, Age, Height and Weight in Byssinosis and Pulmonary Function Models

	VARIABLE	MALE (N = 323)	FEMALE (n= 272)	ALL WORKERS (N = 597)
Byssinosis*	Total Dust	0.002±	0.002±	0.002±
	Age	0.059	0.104*	0.079
	Weight	-0.012+	-0.109*	- 0.01+
	Height	-0.01	0.002	0.033
FEV_1**	Total Dust	0.221±	0.167±	0.207±
	Age	0.095	0.009	0.06
	Weight	-0.07	-0.017	- 0.045
	Height	-0.018	-0.044	- 0.011
FVC***	Total Dust	0.085±	0.044±	0.061±
	Age	0.115	0.015	1.088+
	Weight	-1.029+	0.033	- 0.019
	Height	0.039	0.072	0.048

Lung function was not recorded for 32 subjects.

± $p< 0.001$

+ $p< 0.05$

N.B. For differences between sexes, after allowance for age, height and weight.

*MALE F (1 and 320 d.f.) = 98.96	P<0.000 and R^2 =0.23621
*FEMALE F(1 and 271 d.f.) =44.96	P<0.000 and R^2 =0.14229
** MALE F (1 and 302 d.f.) =52.53	P<0.000 and R^2 =0.14100
** FEMALE F (1 and 257 d.f) =17.2	P<0.0000 and R^2 =0.05967
*** MALE F (1 and 302 d.f.) =22.14	P<0.000 and R^2 =0.06471
*** FEMALE F(1 and 257 d.f.) = 4.05	P<0.0452 and R^2 =0.01472

(Bahir Dar, 1988)

Table IX

Regression Coefficients for Period of Exposure,
Current Cotton Dust Exposure and Cumulative Cotton Dust
Exposure in Byssinosis, Chronic Bronchitis, Bronchial Asthma,
Pulmonary Tuberculosis, Pneumonia, Hay Fever and Pulmonary Function Models

Symptom	Period of Exposure (Months)	Current Exposure Cotton Dust Concentration (mg/m^3)	Cumulative Exposure Cotton Dust Concentration ($mg\ months/m^3$)
Byssinosis	0.002#	0.308#	0.001#
Chronic Bronchitis	0.042**	0.065	3.76 E-04#
Bronchial Asthma	0.066*	0.117	0.075**
Pulmonary Tuberculosis	8.65 E-04	0.011	7.26 E-05*
Pneumonia	0.046	0.055	1.84 E-04+
Hay Fever	7.14 E-04+	0.066	0.077**
FEV_1	0.427	0.054	0.154##
FVC	0.005	0.006	0.06#

# $P < 0.001$

+ $P < 0.01$

* $P < 0.05$

** $P < 0.05$ in one tail test (this is considered since the hypothesis from the outset was unindirectional)

N.B. General Models: $\text{Symptom} = \beta_0 + \beta_1 (\text{age}) + \beta_2 (\text{Sex}) + \beta_3 (\text{height}) + \beta_4 (\text{weight}) + \beta_5 (\text{exposure}) \times \epsilon$

(Bahir Dar 1988)

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II

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