Byssinosis: a follow-up study of cotton ginnery workers in the Sudan

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Khogali, M. (1976). *British Journal of Industrial Medicine*, 33, 166-174. **Byssinosis: a follow-up study of cotton ginnery workers in the Sudan.** A follow-up study of lung function tests and dust measurements was undertaken in ginnery workers employed in five ginning factories. Respiratory symptoms and respiratory function tests (FEV₁ and FVC) were first recorded in 1967 on a total of 382 workers (323 permanently employed ginnery workers, 35 seasonal farfara workers, and 24 fire brigade men as controls). In 1969 after a six-month break from ginning before the start of the season, a follow-up study of lung function tests was undertaken on 96% of the same workers (306 ginnery workers, 35 farfara, and 24 fire brigade men). Because of the lapse of two years a new adjustment for age and height was made so as to compare the FEV₁ measured in the follow-up study. The fire brigade men showed an expected fall in FEV₁ during the two-year period, whereas the ginnery workers showed a rise presumably because they had had no dust exposure during the previous six months. The differences between the degree of change in these groups were statistically significant. In 1967 only the fine dust (< 7 µm) was measured, while in 1969 the concentration of fine and medium dust, that is, less fly was measured. The factories were divided into three groups according to dust concentration. Comparison between the three factory groups and farfara shows a positive association between the level of dust concentration less fly and the prevalence of cough and phlegm. Since age did not appear to be a significant factor in the prevalence of byssinosis, comparisons between permanent workers in these three groups of factories and farfara workers taken separately were made without age standardization. The overall differences were statistically significant. There was a marked trend showing a positive association between prevalence of byssinosis and level of cotton dust concentration in the factories. The correlation between dust levels and the prevalence of byssinosis was nearly perfect when the time factor was included.

The first part of this study was described earlier (Khogali, 1969). It is an epidemiological study which covered the five cotton ginning factories (factories 1, 2, 3, 4, and 5) in the Marigan area in the Sudan. In 1967 a total of 382 men were examined comprising 323 permanent ginnery workers, a random sample of 35 seasonal farfara workers, and a control group of 24 members of the fire brigade. The study showed a prevalence of byssinosis (defined as chest tightness starting on return from the annual holiday and continuing for at least three consecutive days) in 20%

of the ginnery workers and in 48.6% of the farfara workers.

In 1969 after a six-month break from ginning before the start of the season a follow-up study of lung function tests was undertaken on the same workers.

In 1967 only the concentration of fine dusts was measured. But in 1969 both fine (< 7 µm) and medium (7 µm-2mm) dusts were recorded, that is, the concentration of dust, less fly. The concentration, less fly is 'the weight of dust in milligrams per cubic

metre of air, excluding particles which would be caught by a 2 mm wire mesh gauze, wire diameter 0.2 mm, 1.8 mm square aperture' (British Occupational Hygiene Society, 1972).

As described in the previous paper the survey of workers included the observation of symptoms of byssinosis, cough, cough and phlegm, and smoking habits. These were also analysed. The purpose of this paper is to report upon the results of the follow-up study and to discuss the association between the prevalence of byssinosis and other respiratory symptoms with the dust concentration, less fly. Our findings are particularly relevant since the new hygiene standards adopted by the BOHS (British Occupational Hygiene Society, 1972) for cotton dust.

Population and methods

Details of the population, the definition of byssinosis, the measurement of ventilatory capacity, and dust concentration were given in the previous paper, but the features relevant to this paper are summarized below.

The population covered in the follow-up study comprised 365 male workers compared with 382 workers in 1967 (Table 1). These were 48 ginnery workshop workers, 258 ginnery hall workers, 35 seasonal workers, and 24 controls. The 17 not examined were all permanently employed, 13 in the ginnery hall and four in the ginnery workshop. Two had been pensioned, six transferred, and nine were on different training courses. The permanent workers are divided among the five factories while only four factories had farfara sections.

Dust measurement

Dust sampling was carried out at the same sites as in 1967 when the same grades of cotton were ginned. Two hexhlets running in parallel were used (Roach and Schilling, 1960). The horizontal elutriator was removed and replaced by a 7 cm diameter wire gauze with square holes 2 mm $\times$ 2 mm. Air was drawn in by a vacuum pump at the rate of 50 litres per minute. Samples were obtained during an eight-hour period.

The long fibres (> 2 mm) settled on the gauze, that is, coarse dust or fly. The gauze should have been wiped periodically and the coarse dust weighed. However, in the very dusty conditions of the Maringan factories,

especially near the farfara (Fig. 1), it was impractical to do this because the front of the elutriator had to be wiped every half-an-hour to remove the fluffs of cotton, so only fine and medium dusts were measured (dust less fly). The concentration of the medium dust was obtained indirectly.

FIG. 1. The process of farfara.

TABLE 1
POPULATION IN MARINGAN GINNERS IN 1967 AND 1969 BY WORK PLACE AND AGE

Work place	1967			1969		
	No. of workers	Mean age (yr)	Mean job duration (yr)	No. of workers	Mean age (yr)	Mean job duration (yr)
Control	24	35	13	24	37	15
Ginnery workshop	52	32	11	48	34	13
Ginnery hall	271	31	9	258	33	11
Farfara	35	30	6	35	32	8

Classification of smoking habits

Each worker was asked about his smoking habit, and was subsequently classified as follows:

Non-smoker: worker who has never smoked as much as one cigarette a day for one year

Ex-smoker: worker who has smoked but had ceased smoking more than one month before the survey

Smoker:

Grade I 1-4 cigarettes a day

Grade II 5-14 cigarettes a day

Grade III 15 + cigarettes a day.

The number of cigarettes smoked by the smokers is low because smoking is prohibited inside the ginneries area.

Results**Dust concentrations**

The average concentration of fine dust measured in 1967 and the average concentration of both fine and medium dust, that is less fly, measured in 1969 are shown in Table 2. More samples were taken in 1969: a total of 54 in the ginnery halls, 35 in the farfara sections, and 15 in the ginnery workshops compared with ten, eight, and two samples respectively taken in 1967. The highest concentration in 1969 was in the farfara which had a mean concentration of fine dust

of 2.17 mg/m³ and of medium dust of 12.11 mg/m³; the lowest was in the ginnery workshops which had a mean concentration of 0.26 mg/m³ and 0.66 mg/m³ for fine and medium dust. The ginnery halls had a mean concentration of fine dust of 0.90 mg/m³ and of medium dust of 2.64 mg/m³.

In 1967 the mean fine dust concentration in factories 1, 2, and 3 was 0.67, 0.62, 0.58 mg/m³ respectively so they were grouped together. In 1969 these three factories had mean fine dust concentrations of 0.95, 0.86, and 0.81 mg/m³ respectively and were again grouped together. The overall mean concentration in these three factories was 0.89 mg/m³ of fine dust and 2.77 mg/m³ of medium dust. Factory 5 had a mean concentration of 0.45 mg/m³ fine dust and 1.78 mg/m³ medium dust, compared with 1.33 mg/m³ fine dust and 2.98 mg/m³ medium dust in factory 4.

Smoking

The smoking habits and percentages of non-smokers and smokers are shown in Table 3a. Eleven (45.8% of the control group were smokers; of these, 10 had smoked 5-14 cigarettes a day for a mean period of 11.3 years and one had smoked more than 15 cigar-

TABLE 2
DUST CONCENTRATION, CLASSIFIED BY FACTORIES FOR 1967 AND 1969

Site	1967				1969			
	Fine dust < 7 μ m averaging 8 hours mg/m ³				Fine dust < 7 μ m averaging 8 hours mg/m ³			
Factory 5	..	..	..	..	0.42	0.45	1.78	2.23
Factories 1, 2, 3	..	..	..	..	0.62	0.89	2.77	3.66
Factory 4	..	..	..	..	0.86	1.33	2.98	4.31
Farfara	..	..	..	..	2.60	2.17	12.11	14.28

TABLE 3a
SMOKING HABITS CLASSIFIED BY JOB AND FACTORIES (1967)

Work place	No. of workers	Non-smokers		Ex-smokers		All smokers	
		No.	%	No.	%	No.	%
Control	24	13	54.2	—	—	11	45.8
Ginnery workshop	52	38	73.1	3	5.8	11	21.1
Ginnery hall	271	166	61.3	6	2.2	99	36.5
Farfara	35	32	91.4	—	—	3	8.6
Factory 5	55	32	58.2	—	—	23	41.8
Factories 1, 2, 3	193	126	65.3	8	4.1	59	30.6
Factory 4	75	46	61.3	1	1.3	28	37.3

ettes a day for 18 years (Table 3b)). Eleven (21.1%) of the ginnery workshop workers were smokers. Three were grade I smokers for a mean period of 18.3 years, seven were grade II for a mean smoking period of 7.6 years, and only one was grade III. Out of 271 ginnery hall workers 99 (36.5%) were smokers. Out of these 42 were grade I, 51 grade II, six grade III for a mean smoking period of 6.4 years, 7.8 years, and 5.3 years respectively. Only three (8.6%) of the farfara workers were smokers. The permanent workers showed no great differences in their smoking habits and degree of smoking when compared by factories.

Ventilatory function

To compare the occupational groups of the FEV₁ measured in the follow-up study in 1969, a new adjustment for age and height was made. Since the workers were older, the observed FEV₁ were corrected to give the expected value for the new average age of 33 years and a standard height of 171 cm. The

regression of FEV₁ on age, independent of height (b1), was -0.033 to -0.018 litres and the regression of height, independent of age (b2), was $+0.037$ litres per cm with 95% confidence limits of $+0.027$ to $+0.046$ litres.

The mean adjusted FEV₁ for age and height in the occupational groups measured in 1967 and in 1969 after a period of two years, the last six months being free of dust, is shown in Table 4. An analysis of covariance showed that there was no statistically significant difference between the slopes, and the data were pooled to give a common regression line which was used to adjust the mean FEV₁ in the four groups. The overall differences of the mean adjusted FEV₁ were found to be statistically significant at the 0.001 level. The mean change between the FEV₁ measured in 1967 and that measured in 1969 is shown for each group in Table 5. While the control men showed no change in FEV₁ during the two-year period, all the other groups of the ginnery workers showed a rise. When comparisons were

TABLE 3b
GRADES OF SMOKING AND MEAN SMOKING
PERIOD OF SMOKERS AMONG GINNERY WORKERS CLASSIFIED BY WORK PLACE (1967)

Degree of smoking	Control		Ginnery workshop		Ginnery hall		Farfara	
	No. of smokers	Mean smoking period (yr)	No. of smokers	Mean smoking period (yr)	No. of smokers	Mean smoking period (yr)	No. of smokers	Mean smoking period (yr)
Grade I 1-4 cigarettes/day ..	—	—	3	18.3	42	6.4	2	6.5
Grade II 5-14 cigarettes/day ..	10	11.3	7	7.6	51	7.8	—	—
Grade III 15 + cigarettes/day ..	1	18.0	1	13.0	6	5.3	1	4.0
All smokers	11	11.9	11	11.0	99	7.1	3	5.7

TABLE 4
MEAN FEV₁ ADJUSTED FOR AGE AND HEIGHT CLASSIFIED BY WORK PLACE IN 1967 AND 1969

Work place	1967				1969			
	No. of workers	Mean age (yr)	Mean height (cm)	Mean ¹ FEV ₁ adjusted BTPS/ litres	No. of workers	Mean age (yr)	Mean height (cm)	Mean ² FEV ₁ adjusted BTPS/ litres
Control	24	35	177	3.08	24	37	177	3.08
Ginnery workshop ..	52	32	170	3.02	48	34	171	3.38
Ginnery hall	271	31	171	2.77	258	33	171	3.22
Farfara	35	30	167	2.20	35	32	167	2.49

¹Adjusted to a standard age of 31 years and a height of 171 cm.

²Adjusted to a standard age of 33 years and a height of 171 cm; this was measured after 6 months' dust exposure.

TABLE 5
MEAN CHANGE IN FEV₁ DURING A PERIOD OF
TWO YEARS. (THE LAST SIX MONTHS BEING
FREE FROM EXPOSURE TO DUST (1969))

Work place	No. of workers	Mean change FEV ₁ , BTPS/litres	Dust concentration less fly, averaging 8 hours mg/m ³
Control ..	24	- 0.002	—
Ginnery workshop	48	+ 0.30	0.92
Ginnery hall	258	+ 0.43	3.54
Farfara ..	35	+ 0.29	14.28

Statistically significant difference between occupational groups: Control v. ginnery workshop SE (difference) = 0.15; $t=2.00$ $P < 0.05$; Control v. ginnery hall SE (difference) = 0.13; $t = 3.42$ $P < 0.001$.

made between the mean change in FEV₁ of the control men and that of the men in the ginnery workshop the difference was statistically significant ($P < 0.05$); and a highly significant difference was found between the control men and the ginnery hall workers ($P < 0.001$).

Respiratory symptoms and dust concentration

The prevalence of cough and cough with phlegm in the control and in the ginnery workers classified by factories according to dust concentration, less fly, is shown in Table 6. None of the control group had a cough, 9.1% of the permanent workers in factory 5 had coughs, while the prevalence was 17.1% and

24.0% among workers in factories 1, 2, and 3 combined, and factory 4. Only three (8.6%) of the farfara workers had coughs. Since there was little difference in mean age between the workers in the five factories the comparison between workers in factory 5, factories 1, 2, and 3, and factory 4 was made on all ages combined, standardized for smoking habits. The overall differences between the groups were found to be statistically significant ($\chi^2 = 11.0$, $P < 0.02$). There appeared to be a positive association between the prevalence of cough and dust level in the three factory groups, but this did not extend to the farfara workers and therefore no test for linear trend was made.

Cough and phlegm

The prevalence of cough and phlegm classified by smoking habit and job is shown in Table 7a. Applying Cochran's test for difference between percentages, after standardizing for age and job, the difference between smokers and non- or ex-smokers was not statistically significant. The overall differences between jobs standardized for age were highly significant ($P < 0.001$, $\chi^2 = 17.87$). When separate comparisons were made between jobs, standardized for age, statistically significant differences were found between those who worked in the ginnery workshop and the ginnery hall ($P < 0.05$), between the control and the farfara workers ($P < 0.01$), between the ginnery hall and farfara workers ($P < 0.01$), and between the ginnery workshop and farfara ($P < 0.001$).

Since there were statistically significant differences between men employed in the ginnery workshop and those in the ginnery hall new comparisons were

TABLE 6
PREVALENCE OF COUGH, COUGH AND PHEGM, NO RESPIRATORY SYMPTOMS, CLASSIFIED
BY FACTORIES AND RELATED TO DUST CONCENTRATION LESS FLY (1969)

Group	Cough ¹		Cough and phlegm		No respiratory ² symptoms		Dust concentration (less fly) averaging 8 hours mg/m ³
	No.	%	No.	%	No.	%	
Control	—	—	1	4.2	23	95.8	—
Factory 5	5	9.1	2	3.6	39	70.9	2.23
Factory 1, 2, 3	33	17.1	20	10.4	100	51.8	3.66
Factory 4	18	24.0	8	10.7	28	37.3	4.31
Farfara	3	8.6	10	28.6	4	11.4	14.28

¹Overall difference between the groups statistically significant ($\chi^2 = 11.0$, $P < 0.02$).

²Statistically significant differences between factories and all farfara:

Factory 5	v. Factory 1 + 2 + 3	Normal deviate = 2.77 $P < 0.01$
Factory 5	v. Factory 4	Normal deviate = 4.01 $P < 0.001$
Factory 5	v. Farfara	Normal deviate = 5.80 $P < 0.001$
Factories 1 + 2 + 3	v. Farfara	Normal deviate = 4.55 $P < 0.001$
Factories 1 + 2 + 3	v. Factory 4	Normal deviate = 2.01 $P < 0.05$
Factory 4	v. Farfara	Normal deviate = 3.05 $P < 0.01$.

made between factory 4, factories 1, 2, and 3, and factory 5 (Table 6) after standardizing for job. The difference was not statistically significant.

No respiratory symptoms

The proportion of ginnery workers with no respiratory symptoms, classified by factory, is shown in Table 6. Since age did not appear to be a significant factor in the percentage of workers with no respiratory symptoms, comparisons between permanent workers in factory 5, factories 1, 2, and 3, factory 4, and all farfara workers were made on all ages combined. The overall differences, standardizing for smoking habits, were highly significant ($\chi^2 = 38.03$, $P < 0.001$). When separate comparisons were made between the permanent workers in the factories and all farfara workers significant differences were found between factory 5 and factories 1, 2, and 3 ($P < 0.01$), between factory 5 and factory 4 ($P < 0.001$), between factory 5 and farfara ($P < 0.001$), between factories 1, 2, and 3 and factory 4 ($P < 0.05$), between factories 1, 2, and 3 and farfara ($P < 0.001$) and between factory 4 and farfara ($P < 0.01$).

There was some association between freedom

from chest symptoms and the level of dust exposure, but this differed slightly in the two smoking habit groups, the non- and ex-smokers appearing to benefit much more than the smokers from the relatively low level of dust in factory 5 (Table 7b).

Byssinosis

The prevalence of byssinosis classified by smoking habit, age, and occupational group is shown in Table 8. Using Cochran's test, standardizing for age and job, the difference between smokers and non/ex-smokers was not statistically significant. Similarly there was no statistically significant difference between the age groups 15-34 years and 35-54 years after standardizing for job and smoking. The χ^2 test, comparing jobs standardized for age and smoking, showed overall differences to be statistically significant ($\chi^2 = 15.91$, $P < 0.001$).

Table 9 shows the prevalence of byssinosis classified by factories and age groups. Since age did not appear to be a significant factor in the prevalence of byssinosis, comparisons between permanent workers in factory 5, factories 1, 2, and 3, factory 4 and all farfara workers were made on all ages combined.

TABLE 7a
PREVALENCE OF COUGH AND PHLEGM CLASSIFIED BY SMOKING HABITS AND JOB (1967)

Smoking habits	Control Cough and phlegm		Ginnery workshop Cough and phlegm		Ginnery hall Cough and phlegm		Farfara Cough and phlegm	
	No.	%	No.	%	No.	%	No.	%
Non and ex-smokers ..	1	7.7	1	2.4	20	11.6	10	31.25
Smokers	—	—	—	—	9	9.1	—	—
All workers	1	4.2	1	1.9	29	10.7	10	28.6
Dust concentration (less fly) averaging 8 hours mg/m ³	—		0.92		3.54		14.28	

TABLE 7b
PROPORTION OF GINNERY WORKERS WITH NO RESPIRATORY SYMPTOMS
CLASSIFIED BY SMOKING HABITS AND FACTORIES (1969)

Smoking habits	No respiratory symptoms							
	Factory 5		Factory 1, 2, and 3		Factory 4		Farfara	
	No.	%	No.	%	No.	%	No.	%
Non and ex-smokers ..	27	84.4	74	55.2	21	44.7	3	9.4
Smokers	12	52.2	26	44.1	7	25.0	1	33.0
All workers	39	70.9	100	51.8	28	37.3	4	11.4

Factory 5 v. factories 1, 2, and 3 Normal deviate = 2.77 $P < 0.01$
 Factory 5 v. factory 4 Normal deviate = 4.01 $P < 0.001$
 Factory 5 v. farfara Normal deviate = 5.80 $P < 0.001$

The overall differences were statistically significant ($\chi^2 = 9.21$, $P < 0.05$). The prevalence of byssinosis classified by factories and showing the relevant dust concentration and years of exposure is shown in Table 10. There is a marked trend showing a positive association between prevalence of byssinosis and level of dust concentration, less fly, in the factories

(Fig. 2). The χ^2 test for trend, with one degree of freedom, showed a statistically significant trend, $\chi^2 = 9.19$, $P < 0.01$. The regression calculated as a straight line gives a prevalence of 8.2% at 0 dust concentration and 25.48% at a dust concentration of 6.0 mg/m³. The correlation coefficient is + 0.9777. When this relationship was re-examined taking into account

TABLE 8
PREVALENCE OF BYSSINOSIS CLASSIFIED BY SMOKING HABITS, AGE, AND JOBS (1967)

Smoking habits	Ginnery workers		Ginnery hall		Farfara		All ginnery workers	
	No.	%	No.	%	No.	%	No.	%
Non and ex-smokers								
Age 15-34	5	20.8	20	18.5	11	47.8	36	23.1
35-54	1	6.25	11	17.2	4	44.4	16	18.0
Total	6	14.6	31	18.0	15	46.9	52	21.2
Smokers								
Age 15-34	3	50.0	17	23.0	2	66.7	22	26.5
35-54	1	20.0	3	12.0	—	—	4	13.3
Total	4	36.4	20	20.2	2	66.7	26	23.0
All workers								
Age 15-34	8	25.8	37	20.3	13	50.0	58	24.3
35-54	2	9.5	14	15.7	4	44.4	20	16.8
Total	10	19.2	51	18.8	17	48.6	78	21.8

TABLE 9
PREVALENCE OF BYSSINOSIS CLASSIFIED BY AGE AND FACTORIES (1969)

Age	Factory 5		Factories 1, 2, 3		Factory 4		Farfara	
	No.	%	No.	%	No.	%	No.	%
15-34 years	5	13.2	28	21.0	12	28.6	13	50
35-54 years	1	5.9	8	13.3	7	21.2	4	44.4
Total	6	10.9	36	18.6	19	25.3	17	48.6

Statistically significant differences between groups, all ages combined $\chi^2 = 9.21$, $P < 0.05$.

TABLE 10
PREVALENCE OF BYSSINOSIS CLASSIFIED BY FACTORIES AND RELATED TO DUST CONCENTRATION, LESS FLY AND TIME WEIGHTED DUST MEASUREMENT (1969)

Factory	Byssinosis		Years of exposure	Dust concentration (less fly) averaging 8 hours mg/m ³	Time weighted dust measurements mg/years per m ³
	No.	%			
Factory 5 ..	6	10.9	10	2.23	22.30
Factories 1, 2, 3 ..	36	18.6	9	3.66	32.94
Factory 4 ..	19	25.3	11	4.31	47.41
Farfara ..	17	48.6	6	14.28	85.68

FIG. 2. Percentage byssinosis regressed against dust concentration.

FIG. 3. Percentage byssinosis regressed against time-weighted dust measurement.

the years of exposure (time weighted dust concentration) an almost perfect linear trend was found (Fig. 3). The regression line gives a prevalence of -1.75% at 0 dust concentration and 27.75% at 50 mg years/m^3 . The correlation coefficient is $+0.999$.

Discussion

In this study an attempt has been made to relate the prevalence of byssinosis and other respiratory symptoms with the level and duration of exposure to cotton dust.

There appeared to be a positive relationship between the exposure to cotton dust and the symptoms of cough and phlegm (Tables 6, 7). In this study it was difficult to classify the workers complaining of cough and sputum as suffering from chronic bronchitis according to the Medical Research Council classification (1965). The very moderate smoking habits of the Sudanese ginnery workers do not appear to account for the high prevalence of cough and phlegm

(Tables 6, 7) among the workers exposed to cotton dust when compared with the controls, although a higher proportion (45.8%) of the controls smoked compared with ginnery workers (31.6%). In the present study further evidence is given of the noxious effects of cotton dust inhalation on the respiratory tract and its role in the aetiology of cough and phlegm independent of any effects of smoking. Among the farfara workers who were exposed to high concentrations of cotton dust, 28.6% had persistent cough and phlegm, but none was a smoker or ex-smoker (Table 7). Our conclusion is that there is some evidence of association between exposure to cotton dust, less fly, and the development of early bronchitis. This is in agreement with the findings of Berry, Molyneux, and Tombleson (1974) who reported an association between exposure to cotton dust and the development and retention of bronchitis. Fox *et al.* (1973b) reported there was no relationship between cotton dust and the prevalence of bronchitis. However, as Berry *et al.* (1974) observed, the Fox *et al.* (1973b) conclusion was based on a comparison of cotton workers with men working in engineering factories and as two-thirds of the cotton workers were women, a small difference between cotton and non-cotton workers could have been lost.

Byssinosis

There is some evidence from surveys of textile workers that byssinotic symptoms are more prevalent among smokers than among non-smokers (Schilling, 1964; Elwood *et al.*, 1965; Fox *et al.*, 1973a; Merchant *et al.*, 1973; Berry *et al.*, 1974). In the present study the prevalence of byssinosis appeared to be independent of smoking: the difference in the prevalence of byssinosis in smokers, non-smokers, and ex-smokers after standardizing for age and job was not statistically significant (Table 8). This agrees with other studies, where the prevalence of Monday dyspnoea was independent of smoking habits (Belin *et al.*, 1965). In spite of these results the author considers that there is an association with smoking and thinks that the small number of cigarettes smoked by the Sudanese ginnery workers is the reason for his negative findings.

The prevalence of byssinosis is directly related to the level of cotton dust concentration, less fly (Table 10). Although Roach and Schilling (1960) found a correlation between total dust concentration and byssinosis prevalence, more recent evidence has suggested that the relationship with respirable particles, or fly-free dust (medium plus fine fractions) is more relevant (Roach, 1972; British Occupational Hygiene Society, 1972; Fox *et al.*, 1973a; Berry *et al.*, 1974; National Institute of Occupational Safety and Health, 1974). This evidence is strongly supported

in these studies. Thus it seems that the determination of fly-free dust is the most practical method of assessing the environment in cotton ginneries and mills.

Previous studies (Schilling and Roach, 1961; Molyneux and Tombleson, 1970) showed that the effects of differences in duration of exposure were small in comparison with the effects of difference in concentration. Recently Fox *et al.* (1973a) expressed the dose-response relationship in terms of the time-weighted dust measurement (mg years/m^3) that is, dust concentration $\times$ length of exposure in years. Such methods have been used in estimating the threshold limit values of asbestos workers (British Occupational Hygiene Society, 1968). This method was also applied in this study and an almost perfect relationship between the prevalence of byssinosis and the time-weighted dust measurement was found.

Although the association between the incidence of byssinosis and airborne cotton dust is strongly positive, the reasons for the production of symptoms of byssinosis and the changes in ventilatory capacity associated with the disease are not clear. Therefore until the mechanism can be better explained there is a need to use the available knowledge in prevention of over exposure to cotton dust and its noxious effects.

I am greatly indebted to Miss Joan Walford for her statistical help and to Professor R. S. F. Schilling for his advice.

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Received for publication 4 November 1975

Accepted for publication 19 February 1976