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A survey of respiratory disease in cotton operatives

Part I. Symptoms and ventilation test results

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Fox, A. J., Tombleson, J. B. L., Watt, A., and Wilkie, A. G. (1973). *British Journal of Industrial Medicine*, **30**, 42-47. **A survey of respiratory disease in cotton operatives. Part I. Symptoms and ventilation test results.** Between 1966 and 1968, 2 316 operatives were examined in the blow and card rooms of the south-east Lancashire coarse cotton industry. Between 1968 and 1970, a second survey of 2 556 operatives was carried out including 886 of the previous group and also operatives in fine and coarse cardrooms, in ring and winding rooms, and operatives in other parts of the country who were not examined previously.

Symptoms and ventilatory changes of byssinosis were found in operatives in all mills except the two fine cotton mills. Some operatives with less than 10 years' exposure were classified as byssinotic, including 14 in the first survey and 17 in the second who had had less than five years' exposure. These operatives were found in all types of work room.

The 886 operatives examined on two occasions showed a greater deterioration in ventilatory function than a local control population. Even symptom-free operatives showed a 10% excess in the rate of deterioration of $FEV_{1.0}$ with age. But neither the ventilatory tests nor the symptomatic enquiry were of value in predicting the rate of deterioration between the two studies.

Despite improved methods of dust control, exposure to cotton dust continues to cause the symptoms of byssinosis (Roach and Schilling, 1960; Wood and Roach, 1964). Mekky, Roach, and Schilling (1967) showed that subjects developed symptoms of byssinosis in winding rooms in coarse mills. Molyneux and Tombleson (1970), in a prospective survey of blowroom and cardroom workers carried out in 1963-66, analysed the prevalence of symptoms and suggested that symptoms could develop in some subjects after less than 10 years' exposure.

To extend this work, the Medical Services Division (formerly part of HM Factory Inspectorate) have carried out a continuing survey, references to which have appeared in the Annual Reports of the Chief Inspector of Factories since 1967.

Previous work has placed emphasis on establishing the existence of byssinosis in cotton operatives in English mills and on elucidating the role of factors such as workroom, type of cotton, and smoking habit in determining its prevalence. In this paper (Part I) an attempt is made to evaluate periodic medical examinations, while the effect of dust levels and smoking on the development of symptoms and the deterioration in ventilatory capacity will be considered in Part II. The questions to be answered are: (*a*) Are medical examinations, in their present form, useful for predicting those subjects most likely to suffer from chronic disease in the future? (*b*) What is the relationship between subjective measurement, i.e., responses to respiratory symptom questionnaires, and objective measurements of ventilatory

capacity? and (*c*) What other information may be revealed by sequential examination concerning temporal medical changes in individuals and populations exposed to hazardous environment?

Materials and methods

Population

The survey was carried out in two stages. In the first (1966-68), 35 cotton mills were visited, 26 spinning coarse and 9 medium cotton. All were situated in the Rochdale, Oldham, Ashton area. In the second (1968-70), 29 mills, 21 coarse and 8 medium, were re-visited two years after the initial visit and in the same week in the year. In addition, 13 coarse mills, 2 medium mills, and 2 fine mills were visited in other areas of the country, namely, Lancashire, West Riding of Yorkshire, and Scotland. Five of the medium mills included between 30 and 40% rayon with their cotton, and two others did so occasionally. At all the mills operatives in the cardrooms and blowrooms were examined in the middle of the working week. In 11 mills (6 coarse, 3 medium, and 2 fine) the operatives in ring and winding rooms were also examined.

Of the total population available, approximately 10% refused to cooperate. A further 13% had to be excluded. Some of these were absent at the time when the mill was visited and the rest were seen but had to be excluded either because of ethnic difficulties (Cotes and Malhotra, 1965; Cotes, 1968), which made prediction of normal values for ventilatory function impossible, or because of failure to collect all the information necessary for the analysis. Of the 77% included in the analysis, 2 316 were seen on the first occasion and 2 556 on the second. As 886 were seen on both occasions the total population for analysis was 3 986. In order to be sure that the population excluded did not include an exceptionally high proportion of disabled persons the frequency of persons drawing disablement benefit was compared in the included and excluded groups. No difference was found.

Definition of respiratory symptoms and measurements of ventilatory capacity

The Medical Research Council standardized questionnaires on respiratory symptoms (1960), as modified by Roach and Schilling (1960), in conjunction with an occupational history was used to determine whether or not subjects showed symptoms of byssinosis (grade ½ and above), bronchitis (sputum chest-illness syndrome—Lloyd Davies, 1971) and breathlessness (grade 2 and above) (Fletcher, 1952; MRC, 1960).

For the testing of ventilatory capacity, readings of forced expiratory volume in one second ($FEV_{1.0}$), taken as the mean of three competent blows after two trial blows, and forced vital capacity (FVC), the mean of three blows, were estimated using a McDermott dry spirometer.

Predicted values for each individual were calculated from Cotes (1968) regressions for subjects of European descent (Cotes, Rossiter, Higgins, and Gilson, 1966).

Results

The findings are summarized in Tables 1 to 4. In the 'first round' study, 1 087 men and 1 229 women (total 2 316) were examined and in the 'second round' 1 111 men and 1 445 women (total 2 556); 421 men and 465 women (total 886) were seen on both rounds.

Byssinosis (Table 1)

On the first round in the blow and card rooms about 24% had symptoms (13% grade 1 and 5% grade 2) and there was no difference between men and women. In the spinning rooms just over 5% had symptoms (4·5% grade 1 and none grade 2). On the second round the total incidence of symptoms in the blow and card rooms was slightly less (20%) but this was still nearly 5% with grade 2 symptoms. In the spinning rooms there was no definite difference between the two rounds.

TABLE 1

OCCUPATIONAL GROUPS AND FREQUENCY OF SYMPTOMS OF BYSSINOSIS

Room	*Sex*	*Number*	*% in Byssinosis grade*			
			0	½	1	2
Blow and card	M	1 049	76·2	5·2	13·5	5·1
		(916)	(80·2)	(4·3)	(9·5)	(6·0)
	F (full-time)	1 012	78·5	5·5	13·0	3·0
		(825)	(80·5)	(5·8)	(10·2)	(3·5)
	F (part-time)	145	90·3	4·8	4·8	—
Ring	M & F	110	94·5	0·9	4·5	—
	(M)	(149)	(94·6)	(1·3)	(3·4)	(0·7)
	(F)	(324)	(96·9)	(1·5)	(1·2)	(0·3)
Winding	M & F none on 1st round					
	(M)	(46)	(87·0)	(2·2)	(6·5)	(4·3)
	(F)	(296)	(86·5)	(4·1)	(8·1)	(1·4)

2nd round figures in parentheses

The second round included winding room operatives who showed a frequency of symptoms (23%) between that of the card rooms and the spinning rooms. The second round also included 253 operatives from two fine cotton mills and none of these, irrespective of work room, complained of symptoms of byssinosis.

Table 2 shows that the frequency of symptoms rises rapidly with the length of exposure up to 20 years in both surveys. The lower total frequency in long exposure operatives on the second round (22% compared with 31%) may be due to differences in the populations rather than changes in working conditions. A similar association is shown between frequency of symptoms and age (Table 3). The fall

TABLE 2

PREVALENCE OF SYMPTOMS OF BYSSINOSIS IN RELATION TO DURATION OF EXPOSURE

Years in job	*Number examined*	*% with symptoms of byssinosis*
0– 4	488 (504)	3 (3)
5– 9	240 (320)	8 (7)
10–14	272 (263)	19 (16)
15–19	326 (335)	28 (21)
20+	990 (1 134)	31 (22)
Total	2 316 (2 556)	21 (16)

2nd round figures in parentheses

in frequency in the over 60 years age group may be due to early retirement of women and the more disabled men.

The effect of smoking on the frequency of the symptoms of byssinosis is not so straightforward (Table 4). Although operatives who have never smoked show the lowest frequency (14% and 9% in the two rounds), the heaviest smokers (grade 3) are nearly as low (21% and 15%). There is no doubt that the operatives developing byssinotic or bronchitic symptoms are more likely to give up or reduce their smoking. This may account for the relatively high incidence of symptoms in the ex-smoker group (24% and 21%) and the highest frequency of grade 2 byssinotics (7·6% and 5·6%).

The symptoms of byssinosis cannot be dissociated entirely from those of other chronic airways diseases or regarded as the specific result of exposure to cotton dust. In this survey the frequency of bronchitic symptoms (the sputum chest-illness syndrome)

TABLE 4

EFFECT OF SMOKING ON PERCENTAGE OF WORKERS WITH SYMPTOMS OF BYSSINOSIS

	Number	*% in byssinosis grade*			
		0	½	1	2
Non-smoker ..	731 (865)	86·0 (91·0)	5·0 (2·9)	8·0 (5·2)	1·1 (0·9)
Ex-smoker ..	147 (142)	75·8 (78·9)	5·7 (7·7)	10·8 (7·7)	7·6 (5·6)
Smoker					
Grade 1 ..	886 (917)	77·9 (80·5)	5·0 (4·9)	12·6 (9·5)	4·5 (5·1)
Grade 2 ..	487 (567)	70·5 (80·8)	6·2 (4·2)	18·8 (10·4)	4·5 (4·6)
Grade 3 ..	65 (65)	78·5 (84·6)	1·5 (3·1)	16·9 (7·7)	3·1 (4·6)

2nd round figures in parentheses

Non-smoker — Subject who has never smoked as much as one cigarette per day or 1 oz. of tobacco a month, for as long as one year

Ex-smoker — Subject who has smoked (see 'non-smoker') and who ceased smoking more than one month before examination

Smoker grade 1 — 1–14 cigarettes per day and/or up to 3 oz. tobacco per week

2 — 15–24 cigarettes per day and/or up to 6 oz. tobacco per week

3 — 25+ cigarettes per day and/or 6 oz. or more tobacco per week

The definition of 'ex-smoker' was inadequate for the purposes of detailed analysis because it took no account of

(*a*) the number of years since the subject last smoked;

(*b*) the subject's grade when he smoked;

(*c*) the reasons for the subject giving up smoking.

The last of these may possibly be the most important because a large number of people give up smoking when they notice an adverse effect on their health.

TABLE 3

PREVALENCE OF SYMPTOMS OF BYSSINOSIS IN RELATION TO AGE

Age group	*Number examined*	*Per cent byssinotic*
15–19	177 (165)	1 (2)
20–24	113 (144)	4 (2)
25–29	138 (152)	11 (6)
30–34	211 (208)	21 (11)
35–39	228 (225)	23 (19)
40–44	300 (310)	29 (21)
45–49	271 (393)	24 (21)
50–54	256 (258)	24 (18)
55–59	368 (435)	29 (21)
60+	254 (266)	19 (16)
Total	2 316 (2 556)	21 (16)

2nd round figures in parentheses

was quite high (8% on the first round and 6·3% on the second). Table 5 shows that in both rounds there was a definite association between byssinotic and bronchitic symptoms. The tendency for byssinotics to have bronchitic symptoms was highly significant in both rounds of the survey.

Subjects examined twice

All the 421 men and 465 women in this group were blow and card room workers. Five who had been ex-smokers and five non-smokers had become smokers and 24 smokers had stopped smoking. Otherwise there were very few changes; a few changed their job within the same general description and on the average they were all two years older.

Symptoms of byssinosis showed little change beyond what would be expected from random variation. The majority (604) were symptom-free on both

TABLE 5

ASSOCIATION OF SYMPTOMS OF BYSSINOSIS AND BRONCHITIS

	Byssinosis grade				
	0	½	1	2	*Total*
First round					
With bronchitis	111	6	44	25	186
Without bronchitis	1 717	113	242	58	2 130
Total	1 828	119	286	83	2 316

$\chi^2 = 86{\cdot}89079$
P = <0·001

Second round					
With bronchitis	99	4	30	27	160
Without bronchitis	2 051	103	177	65	2 396
Total	2 150	107	207	92	2 556

$\chi^2 = 118{\cdot}02409$
P = <0·001

occasions and altogether 114 showed an increase in symptoms and 91 a decrease (Table 6). The associated changes in $FEV_{1\cdot0}$ (Table 7) correlate fairly well with the changes in byssinosis grade. All but one of the groups showing no change in byssinosis grade showed a slight fall in $FEV_{1\cdot0}$, those with the worst initial grade showing the greatest fall in FEV. The groups showing an improvement in byssinosis grade showed an improvement or slight fall in FEV while those with deteriorating grades all showed

TABLE 6

SUBJECTS EXAMINED TWICE: CHANGES IN BYSSINOSIS GRADE

Grade on 1st round	*Grade on 2nd round*				
	0	½	1	2	*Total*
0	**604**	23	40	10	677
½	22	**18**	13	3	56
1	36	18	**39**	25	118
2	6	1	8	**20**	35
Total	668	60	100	58	886

Summary of changes		
	Three categories better	6
	Two categories better	37
	One category better	48
	None	681
	One category worse	61
	Two categories worse	43
	Three categories worse	10

TABLE 7

MEAN CHANGE IN $FEV_{1\cdot0}$ IN APPROXIMATELY TWO YEARS

Grade on 1st round	*Sex*	*Grade on 2nd round*			
		0	½	1	2
0	M	−0·028	−0·055	−0·133	−0·214
	F	−0·041	−0·127	−0·125	−0·230
½	M	+0·113	+0·042	−0·213	(−0·040)
	F	+0·043	−0·030	−0·070	(−0·100)
1	M	+0·007	−0·143	−0·123	−0·357
	F	−0·023	−0·003	−0·001	−0·022
2	M	+0·386		−0·044	−0·163
	F	(+0·002)	(0·000)	(−0·130)	−0·158

N.B. Figures in parentheses are based on less than 5 observations

a fall in FEV which was as great as 0·35 litres in one group. The numbers in some groups are too small to permit formal analysis.

There was random variation in the grading of breathlessness and the grading of sputum chest illness syndrome. A general correlation between the grading of byssinosis and the chest illness syndrome has already been shown for the two rounds separately (Table 5) and the same correlation was found for the patients examined twice. However, many workers showed a reduction in one symptom and an increase in another so that all combinations of change occurred, making formal analysis unprofitable because of the small numbers involved in each category (see Table 8).

Of the two tests of ventilatory capacity carried out, the $FEV_{1\cdot0}$ showed a more consistent change between the two examinations than the FVC as well as correlating more closely with the symptoms. Therefore the changes in $FEV_{1\cdot0}$ in those workers

TABLE 8

VARIATION IN BYSSINOSIS GRADING AND BREATHLESSNESS GRADING ON THE TWO ROUNDS OF THE SURVEY: NUMBERS OF WORKERS

Breathlessness of grade 2 or over	*Byssinosis of grade ½ or over*			
	Neither round	*1st round only*	*2nd round only*	*Both rounds*
Neither round ..	286	13	15	17
1st round only ..	79	10	6	23
2nd round only ..	75	8	7	12
Both rounds ..	164	33	45	93

(277) who were symptom-free on the first examination were used to compare this occupational group with a control Lancashire population (Lloyd Davies, 1971). In the Figure the regression lines for change of $FEV_{1\cdot0}$ (expressed as a % of predicted normal) against time are shown. Normal individuals should remain as predicted because the prediction is corrected for age: therefore normals are represented by the horizontal line at 100%. The control Lancashire population drawn from engineering factories (broken line) are seen to deteriorate very slightly more rapidly than predicted normals. The symptom-free cotton workers deteriorate 10% more rapidly than both the predicted normal and the engineering workers.

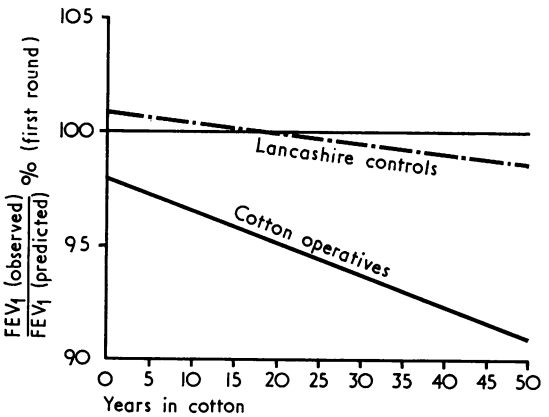

FIGURE Effect of cotton dust on forced expiratory volume.
Lancashire controls (172 males)

$$\% = 100{\cdot}41 - 0{\cdot}0235 \times \text{years}$$

Cotton operatives, symptom-free on first of two examinations (277 males and females)

$$\% = 97{\cdot}79 - 0{\cdot}14 \times \text{years}$$

Discussion

Prevalence studies have thrown considerable light on the problem of byssinosis and the factors which lead to this disease. The present study confirms the continued presence of byssinosis in coarse and medium cotton mills. Although the prevalence is highest in blow and card rooms (26%), the disease occurs appreciably in winding (14%) and also ring spinning rooms (4%). It also shows that the prevalence of disease increases with exposure and is affected by smoking. Symptoms were found in 31 operatives who had less than five years' exposure and in 5% with less than 10 years' exposure.

Apart from indicating the continued presence of the hazard it is not possible to determine whether the risk in the Lancashire cotton mills has changed by comparing the results of either round of the present survey with previous surveys. However, the inclusion of a group of 886 workers in both rounds of the survey gives some indication as to whether workers show the expected increase in symptoms with two further years' exposure. The re-examination has also made it possible to estimate the value of periodic medical examinations in this industry. Although the changes in $FEV_{1\cdot0}$ indicate that as far as their ventilatory function is concerned these workers are still deteriorating faster than the control population, the analysis of symptoms on the two occasions is not so informative. The grading of symptoms of bronchitis, breathlessness, and the sputum chest illness syndrome is subject to considerable variation and the two-year interval between the two examinations is insufficient for a detectable change to occur. Although most of the workers with high symptomatic grading on the first round were found in a high grade on the second round, the first examination could not be relied upon to identify those with serious progressive disease. This is partly due to the random variation in the symptoms and partly to the slow rate of increase.

This survey, like other prevalence surveys, is based on a survivor population from which those unable to tolerate the working conditions have been weeded out already. This applies also to the population of workers examined on two occasions which excluded workers leaving the mills between the two visits. It is not justifiable to conclude from these results that periodic medical examination at two-yearly intervals is of sufficient value to identify those who ultimately will have to leave the industry because of progressive symptoms. It will be necessary to continue the investigation in the form of a cohort study to determine whether periodic medical examination is of value and to estimate the true incidence of disease in this population, including all the people who have left the industry.

Mill management and operatives have been most helpful and without their cooperation the survey could not have been made. Our thanks are given to the British Textile Employers' Association, the National Union of Textile and Allied Workers, the Amalgamated Weavers' Association, and the Amalgamated Association of Operative Cotton Spinners and Twiners for their support.

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