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A study of rope workers exposed to hemp and flax

G. F. SMITH, G. V. COLES, R. S. F. SCHILLING, AND JOAN WALFORD

The Medical Branch of H.M. Factory Inspectorate and the London School of Hygiene and Tropical Medicine T.U.C. Centenary Institute of Occupational Health

Smith, G. F., Coles, G. V., Schilling, R. S. F., and Walford, Joan (1969). *Brit. J. industr. Med.*, **26**, 109-114. **A study of rope workers exposed to hemp and flax.** Respiratory symptoms and ventilatory capacities were studied in 54 men and 22 women exposed to the mixed dusts of hemp and flax in an English rope factory. The preparers and most of the spinners were exposed on average to concentrations of 1·7 mg./m.^{3} total dust and 0·5 mg./m.^{3} fine dust. Those employed on subsequent processes had lower exposures at concentrations of 0·5 mg./m.^{3} total dust and 0·1 mg./m.^{3} fine dust.

Six men, all in the high exposure group, had symptoms of byssinosis. After adjustment for age and standing height there was no statistically significant difference in the forced expiratory volume ($F.E.V._{1\cdot0}$) between those in high dust concentrations and those in low concentrations; neither was there a significant difference between the ventilatory capacities of men with and without byssinosis.

This study shows that byssinosis is an occupational hazard confined to male workers in this factory. It does not appear to be a very serious problem and will diminish with the increasing use of synthetic materials instead of natural fibres.

Ropes and twines are made from various fibres of which flax and soft hemp (*Cannabis sativa*) were among the first to be used and have long been known to cause chronic respiratory disease (Ramazzini, 1713). The term 'byssinosis' was first given to the respiratory disease of cotton workers in the nineteenth century (Massoud, 1964), and in Great Britain cotton workers have been eligible for compensation since 1942. Recent research has revealed that the disease suffered by flax and hemp workers is indistinguishable from byssinosis (Werner, 1955; Mair, Smith, Wilson and Lockhart, 1960; Smiley, 1961; and Elwood, Pemberton, Merrett, Carey and McAulay, 1965). The occurrence of severe and disabling byssinosis among workers in Spain and Yugoslavia making ropes with soft hemp has been clearly shown by Bouhuys, Barbero, Lindell, Roach and Schilling (1967), and Valić, Žuškin, Walford, Keršić, and Pauković (1968). In two recent studies in England, workers making rope from manilla, sisal, and St. Helena hemp had no symptoms of byssinosis; some, however, had symptoms of chest tightness and a fall in ventilatory capacity during the working day, but there was no evidence of severe disability (Munt, Gauvain, Walford, and Schilling, 1965; and McKerrow, Gilson, Schilling, and Skidmore, 1965).

Following the investigations of Elwood and his colleagues (*op. cit.*) in the flax mills of Northern Ireland, flax workers in the dusty processes of preparing fibres have been included in the compensation scheme for byssinosis. Little soft hemp is used in Great Britain and workers exposed exclusively to it would not be eligible for compensation.

The factory selected is situated in a town which has long been a centre for rope making, there being

evidence of a rope industry in Roman and Phoenician times supported by the local cultivation of hemp and flax. At the present time, the making of rope and twines is concentrated in a few factories. In the one studied, soft hemp and flax are mainly used, although the amount is diminishing in favour of synthetic fibres. The continued use of flax and soft hemp justified a survey of byssinosis among the largely static population, some of whom were known to have been exposed to hemp and flax dust for many years.

Description of process

About 35% of the natural fibres handled at the factory is Belgian flax (*Linium vsitatissium*) and 65% is Russian soft hemp (*Cannabis sativa*). These are combed and baled in the countries where they are grown.

After the bales have been opened, the fibres are loosened and parted, the hemp being lubricated with oil; this is not necessary for flax because of its natural oil content. The best flax is straightened on a hackling machine (Fig. 1); the lower grades and all the hemp are carded to produce a sliver of parallel fibres (Fig. 2). These slivers are then 'prepared' on 'doubling' machines to produce a blended ribbon, which is conveyed to the spinning machines (Fig. 3). After spinning, the twine is rewound on 'cops' to recover the bobbins. Twisting and cabling are done on cabling machines, which have replaced the travelling trolleys formerly used in the rope walks. The lower grade thread is dipped in glue size and polished by gentle abrasion.

Opening and hackling are confined to a separate room, whilst carding, preparing, spinning, and 'cop' winding all take place in three large, freely interconnecting workshops. Cabling, twisting, and polishing are carried out in separate buildings as are net fitting and packing. Exhaust ventilation is applied to the hackling and carding machines, to two of the spinning frames, and to 'cop' winding. Visible dust in the air was most evident at the feeding end of the carding and hackling machines.

Population and methods of study

The opening of bales and the loosening, hackling, and carding of fibres are undertaken by men; all the other jobs are done by men and women. It was not possible to find a group exposed only to hemp because flax and hemp are handled at the same time. Seventy-six (90·2%) of the 57 men and 26 women employed were included in the survey. These subjects were divided as far as possible equally between the two observers (G.F.S. and R.S.F.S.). Of the four women not seen, three refused to take part and one was ill; the three men not seen were all off sick. None of those absent had a chest illness. The age distribution of the men differed slightly from that of the women

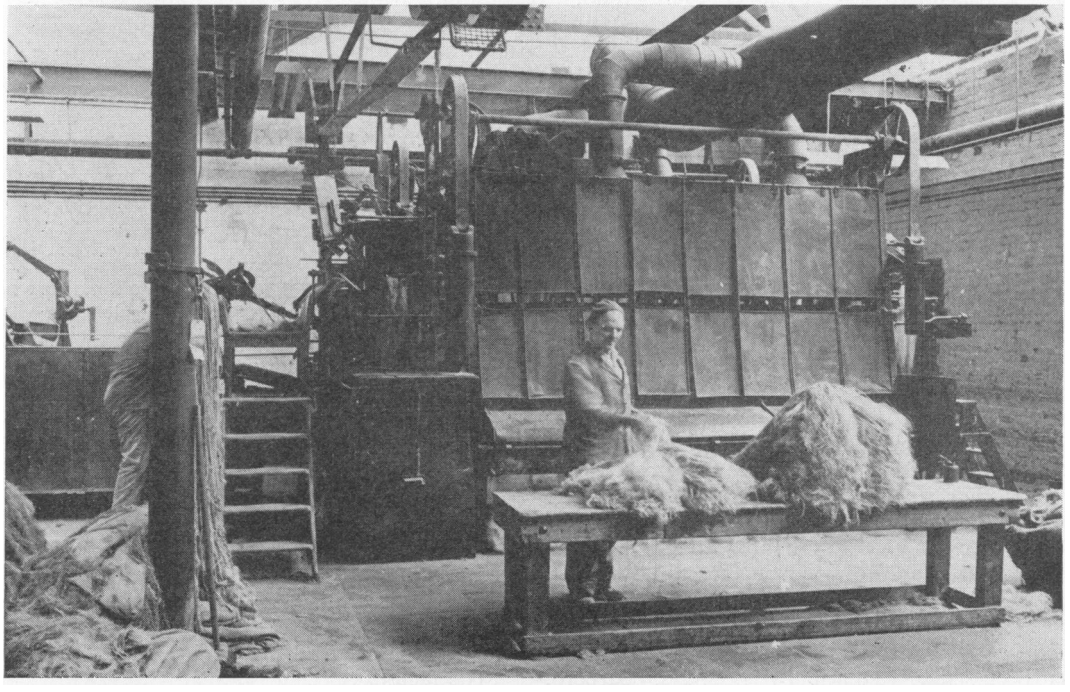

FIG. 1. 'Piecing out' of raw flax with hackling machine in the background.

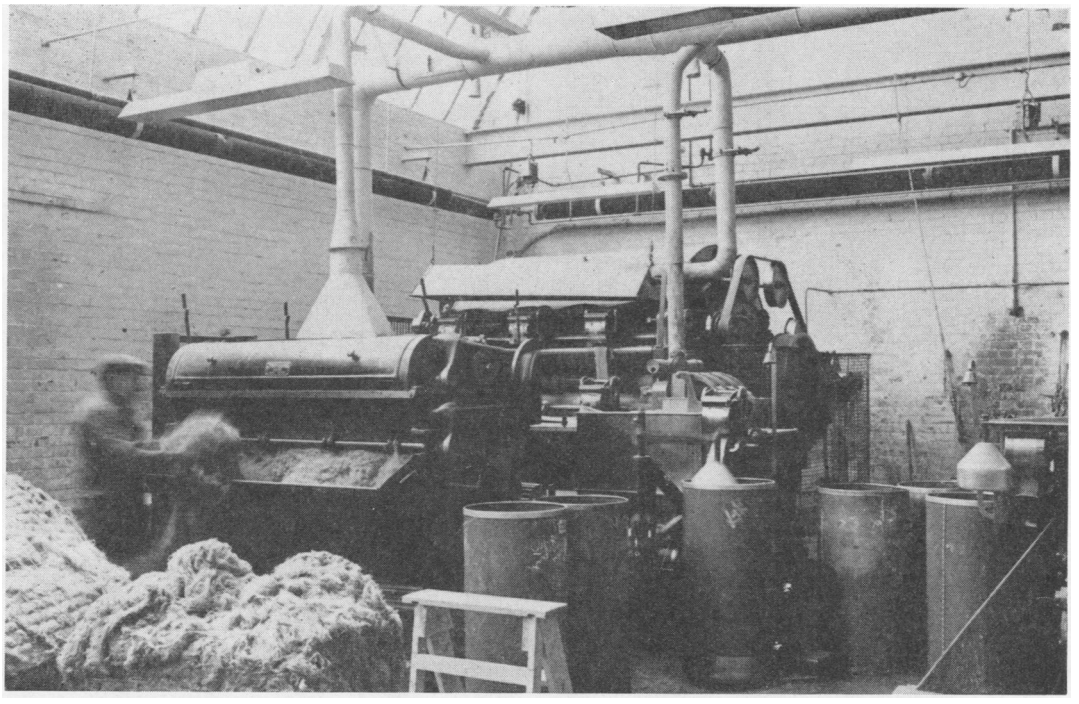

FIG. 2. Carding machine for flax and hemp.

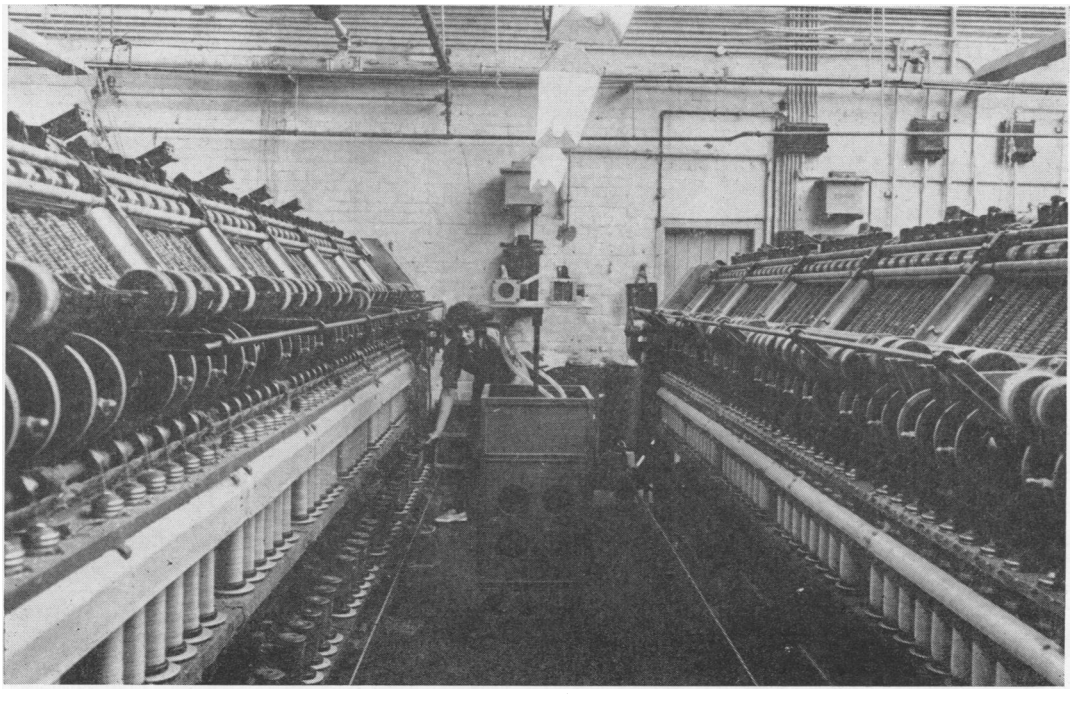

FIG. 3. Inclined spinning machines for flax and hemp showing Hexhlet-Soxhlet apparatus collecting dust samples.

TABLE 1

AGE DISTRIBUTION OF MALE AND FEMALE ROPE WORKERS

Age (years)	*Males*		*Females*	
	No.	*%*	*No.*	*%*
–20	9	16·7	6	27·2
20–	1	1·9	1	4·5
30–	8	14·8	2	9·1
40–	12	22·1	4	18·3
50–	20	37·1	7	31·8
60–	4	7·4	2	9·1
	54	100·0	22	100·0

of whom a higher proportion were under 30 years of age (Table 1).

Dust concentrations

Airborne dust was collected by means of a combined Hexhlet-Soxhlet sampler and was size-graded according to the method described by Roach and Schilling (1960). Concentrations are expressed in terms of total dust, that is all particle sizes, and fine dust which contains particles of less than 7·1 μ equivalent diameter. Twenty-seven samples were taken, mostly in areas assessed visually as the dustiest. The majority of samples were taken over 4-hour periods, but the shortest period was 1½ hours and the longest 8 hours taken in areas apparently free from dust.

Respiratory symptoms

A history of chest disease, respiratory symptoms, and smoking habits was recorded for each worker, using the Medical Research Council questionnaire for bronchitis extended to include the diagnosis and grading of byssinosis (Lammers, Schilling, and Walford, 1964).

Respiratory function tests

The forced expiratory volume over one second ($F.E.V._{\cdot1\cdot0}$) was measured with a water-sealed spirometer and timer; the time of day, water temperature, and the standing height and weight of each subject were also recorded. The procedure was the same as that used in previous investigations (McKerrow, McDermott, Gilson, and Schilling, 1958). Respiratory function was measured in all the men, but three women did not do these tests although they answered the questionnaire.

Results

Dust concentrations

Low dust concentrations were found in precision winding, twisting, cabling, polishing, and net fitting; the average concentrations were 0·4 mg./m.^{3} for total dust, and 0·1 mg./m.^{3} for fine dust. Higher concentrations were produced by opening, hackling, carding, preparing, spinning, and 'cop' winding, with mean values of 1·7 mg./m.^{3} for total dust and 0·5 mg./m.^{3} for fine dust (Table 2).

Chest symptoms

The prevalences of persistent cough, persistent phlegm, chronic bronchitis, and byssinosis in workers exposed to high and low concentrations of dust are shown in Table 3. The smallness of the groups prevented standardization for age and smoking habits. The men in the high dust exposure group were on the average two years older than those exposed to low dust concentrations but a slightly lower proportion of them were smokers. The women showed the reverse pattern; the group working in high dust exposures were on the average younger and more of them smoked.

The men and the women exposed to high concentrations of dust had a higher prevalence of persistent cough and of persistent phlegm than those exposed to low dust concentrations. The differences between the two exposure groups were more marked in the women but none of them was statistically significant. Four men, all smokers, gave a history of chronic bronchitis; its prevalence was similar in the high and in the low dust exposure groups. None of the women had chronic bronchitis or byssinosis. Six men had symptoms of byssinosis, and all were in the high dust exposure group. Fisher's exact test gave the probability of this result occurring by chance as $P = 0{\cdot}006$.

Lung function tests

The mean observed $F.E.V._{\cdot1\cdot0}$ for high and low dust exposure groups, and for men without byssinosis, were adjusted by the regression of $F.E.V._{\cdot1\cdot0}$ on age and standing height (Table 4). Observed and adjusted mean values are given together with the expected

TABLE 2

MEAN DUST CONCENTRATIONS IN THE ROPE WORKS

Dust category	*No. of workers*	*No. of samples*	*Fine dust (mg./m.^{3})*		*Total dust (mg./m.^{3})*	
			Mean	*Range*	*Mean*	*Range*
High dust	16 men 10 women	16	0·5	0·2–1·3	1·7	0·6–5·1
Low dust	38 men 12 women	11	0·1	0·0–0·2	0·4	0·0–1·0

TABLE 3

RESPIRATORY SYMPTOMS, MEAN AGE AND PERCENTAGE OF SMOKERS IN MALE AND FEMALE WORKERS EXPOSED TO HIGH AND LOW DUST CONCENTRATIONS

	No. of workers	*Mean age (years)*	*Persistent cough*		*Persistent phlegm*[1]		*Chronic bronchitis*[2]		*Byssinosis*		*Smokers*	
			No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Men	54	47	14	25·9	12	22·2	4	7·4	6	11·1	39	72·2
High dust	16	48	5	31·3	4	25·0	1	6·3	6	37·5	11	68·8
Low dust	38	46	9	23·7	8	21·1	3	7·9	0	0·0	28	73·7
Women	22	44	4	18·2	2	9·1	0	0·0	0	0·0	7	33·8
High dust	10	41	3	30·0	2	20·0	0	0·0	0	0·0	4	40·0
Low dust	12	47	1	8·3	0	0·0	0	0·0	0	0·0	3	25·0

[1]Cough or phlegm on most days for as much as three months each year.
[2]Chronic bronchitis is defined as persistent phlegm and at least one chest illness causing absence from work during the last three years.

TABLE 4

MEAN OBSERVED F.E.V. AND AGE AND HEIGHT ADJUSTED FORCED EXPIRATORY VOLUME IN MALE AND FEMALE WORKERS

	No. of workers	*Mean age (years)*	*Mean standing height (cm.)*	*Mean observed* $F.E.V._{1\cdot0}$ *(l.)*	*Mean adjusted* $F.E.V._{1\cdot0}$ *(l.)*	*Mean expected* $F.E.V._{1\cdot0}$ *(l.)*	*Mean* $\frac{F.E.V._{1\cdot0}\ observed \times 100}{expected}$ *%*
Men							
High dust	16	48	170	2·86	2·80	3·36	85
Low dust	38	48	169	2·99	3·01	3·32	90
Byssinotics	6	50	171	2·75	2·75	3·34	82
Non-byssinotics	48	48	169	2·98	2·98	3·32	90
Women							
High dust	9	40	156	2·34	2·34	2·40	97
Low dust	10	48	160	2·21	2·21	2·32	95

[1]The pooled regression of $F.E.V._{1\cdot0}$ on age independent of height was for men $b_1 = -0{\cdot}032$ and for women $b_1 = -0{\cdot}020$ l./year, and that for height independent of age was for men $b_2 = +0{\cdot}049$ and for women $b_2 = +0{\cdot}043$ l./cm.

normal values calculated for men and women respectively from the regression equations of Kory, Callahan, Boren, and Syner (1961) and Ferris, Anderson, and Zickmantel (1965).

The difference in adjusted mean $F.E.V._{1\cdot0}$ between the high and low dust exposure groups was not statistically significant in either the men or women. Nor was the difference between men with and without byssinosis. When the observed mean $F.E.V._{1\cdot0}$ is expressed as a percentage of the normal predicted value none of the mean ratios falls below 80%, although the mean ratio for the men with byssinosis is lower than that of the other group.

Byssinosis

Data on the six men in the high exposure group who gave histories characteristic of byssinosis are summarized in Table 5. One had been a preparer for two years. All the others had had long exposures to dust, ranging from 16 to 44 years. All had smoked at some time or other for at least 10 years. One man had a past history of attacks of respiratory disease, apart from symptoms of byssinosis. While three men were permanently affected with effort intolerance, only two showed any reduction in $F.E.V._{1\cdot0}$.

Discussion

The results indicate that byssinosis is an occupational hazard in this rope works, but none of the six men with symptoms of the disease was seriously affected apart from one with a long-standing history of bronchitis. He had a low $F.E.V._{1\cdot0}$ which was 48% of the normal predicted value. It seems likely that any disability that he may have had from dust exposure had been exacerbated by respiratory

TABLE 5

SYMPTOMS AND LUNG FUNCTION IN SIX MEN WITH BYSSINOSIS

Case	Age (years)	Occupation	Total exposure to dust (years)	Persistent cough		Grade of dyspnoea[1]		Grade of byssinosis[2]	Observed $F.E.V._{1\cdot0}$ (l.)	% of expected value of $F.E.V._{1\cdot0}$
				Sputum	No sputum	Weekend	Monday			
1	62	Preparing	21		+	1	1	½	2·03	71
2	50	Preparing	2		+	1	2	1	3·27	93
3	62	Preparing	44	+		2	2	1	1·33	48
4	47	Carding	34		+	1	2	1	2·8	92
5	50	Carding	21		+	3	4	2	3·7	106
6	31	Spinning	16			2	3	2	3·34	83

[1]Dyspnoea grade is defined as:
1 Normal—no shortness of breath when hurrying on the level or on walking up a slight hill;
2 Slight—shortness of breath when hurrying on the level or walking up a slight hill;
3 Moderate—shortness of breath when walking with others at an ordinary pace on the level;
4 Severe—having to stop for breath when walking at own pace on the level.

[2]Byssinosis grade is defined as:
½ Occasional tightness on Mondays;
1 Chest tightness and/or difficulty in breathing on every Monday at work;
2 Chest tightness and/or difficulty in breathing on Monday and other days.

infection. Apart from byssinosis, which was found only in the men with relatively high dust exposures, there is no statistically significant difference in the prevalence of respiratory symptoms in the groups with different exposures to dust. Nor is there any evidence that dust exposure has so far been sufficient to cause any major effect on the ventilatory capacities, such as that found in other groups of rope workers exposed to the dust of soft hemp.

Dust concentrations were substantially lower than those in Spain and Yugoslavia, where byssinosis was much more prevalent and more severe. In this English factory, it was only in the preparing, carding, and spinning sections that concentrations of total dust were greater than 1 mg./m.^{3} The average concentration of 1·7 mg./m.^{3} is about half that found in similar work rooms in the Spanish and Yugoslavian factories (Bouhuys *et al.*, 1967; and Valić *et al.*, 1968).

The increasing use of synthetic fibres has undoubtedly diminished the risk of byssinosis, which will disappear altogether in this industry if synthetic materials entirely replace flax and soft hemp.

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