STUDY OF RESPIRATORY SYMPTOMS AND VENTILATORY CAPACITIES AMONG ROPE WORKERS

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In a rope works handling manila, sisal, and St. Helena hems, the prevalence of respiratory symptoms and the change in forced expiratory volume (F.E.V._{1.0}) during the work shift were studied in a group of 41 women and 41 men who represented 93% of the population at risk.

Dust concentrations, measured with a modified Hexhlet, ranged from 0.11 to 4.51 mg./m.³ for total dust and 0.02 to 1.46 mg./m.³ for fine dust. The highest concentrations were found in the preparing rooms, in which the workers, all of whom were women, showed on the average a fall in ventilatory capacity during the shift. The workers in the rope walk, all of whom were men, showed a rise in ventilatory capacity during the shift. The difference between the men and women was statistically significant ($P < 0.05$). No worker gave a characteristic history of byssinosis, although nine women complained of chest tightness associated with their work.

Undue breathlessness on exertion and persistent cough and phlegm were also more common among the women, but they were on the average 18 years older than the men. When the ventilatory capacities and the prevalence of respiratory symptoms of women rope workers were compared with those of a group of women employed elsewhere in the dockyard, the only significant difference was that the rope workers had more chest tightness associated with their work ($P < 0.02$).

Exposure of volunteers to St. Helena hemp, which is apparently the most likely of the hard hems to give rise to respiratory symptoms, caused only a slight fall in ventilatory capacity and a small rise in airways resistance.

A sample of St. Helena hemp assayed on guinea-pig ileum had only a relatively small degree of contractor activity. The evidence suggests that the dusts of hard hems do not cause byssinosis under the conditions in this factory. However, the irritant nature of the dust indicates the need to prevent total dust levels exceeding about 2 mg./m.³.

Since flax and hemp dusts were first described as a cause of asthmatic troubles by Ramazzini (1713) there have been many studies of the ill-effects of vegetable dusts (Purdon, 1873; Collis, 1909; Schilling, 1956; Mair, Smith, Wilson, and Lockhart, 1960; El Batawi, 1962; Schilling, Vigliani, Lammers, Valic, and Gilson, 1964). They deal mostly with cotton and flax, both of which may cause byssinosis, an industrial pulmonary disease characterized by chest tightness at the beginning of the working week. Much less is known about the effects of hemp dust on the respiratory tract which Ramazzini reported as less severe than those of flax.

Both Werner (1955) in France and Nelson in Ireland (personal communication) have described byssinosis symptoms among workers using mixtures

of hemp and flax in making ropes and twines. Smiley (1951) has also described the immense amount of dust in the preparing rooms of rope works, causing a condition known as 'pousse' which resembles byssinosis. More certain evidence that hemp itself may cause byssinosis comes from Spain where Jiménez Díaz and Lahoz (1944) have described a condition called cannabosis which appears to be the same disease as byssinosis with the characteristic history of chest tightness on Mondays.

The risk of respiratory disease from handling hemp fibres is confused because there are two distinct types of hemp: the soft fibres derived from the stem of the plant and hard fibres derived from the leaf (Table 1). Although there is evidence from the work of Jiménez Díaz and Lahoz (1944) in Spain

TABLE 1

HEMP FIBRES USED IN MAKING ROPES AND TWINES

Soft Fibres (from plant stem)	
<i>Cannabis sativa</i>	Chilean, Italian and Russian hemp; also produced in Bulgaria, France, Hungary, Sweden and Yugoslavia
<i>Crotalaria juncea</i>	Sunn or Indian hemp
Hard Fibres (from leaf)	
<i>Agave sisalana</i>	Sisal hemp
<i>Agave fourcroydes</i>	Henequen produced in Mexico, Cuba, and El Salvador
<i>Furcraea gigantea</i>	Mauritius hemp
<i>Musa textilis</i>	Manila hemp or Abaca; also produced in Borneo and Central America
<i>Phormium tenax</i>	New Zealand or St. Helena hemp

and from a more recent survey of rope workers in Yugoslavia by Valic and Walford (personal communication) that dust from soft hemp (*cannabis sativa*) may cause byssinosis, there is little evidence that this disease may occur from exposure to hard fibre dust other than a negative finding that Africans processing sisal did not appear to have byssinosis (Stott, 1958; Gilson, Stott, Hopwood, Roach, McKerrow, and Schilling, 1962). It was therefore decided to survey rope workers employed in a Royal Naval dockyard where only hard fibres are used and where there would be no language difficulties in taking histories of symptoms.

The ropery attached to this dockyard has been working since 1730 making rope and twine exclusively for ships of the Royal Navy. The ropery itself and the processes used for making rope have changed very little since the last century. However, in 1935 hard fibres almost completely replaced the Russian and Italian soft hems. Only relatively small quantities of soft hems, varying between 1 and 5% of all fibre materials, continued to be used until 1956, since when they have not been used at all. According to the ropery manager, a noticeable lack of chest complaints followed this change; when nothing but Russian or Italian hemp was used many workers complained of their chests.

Description of Process

Manila, sisal, and St. Helena hems, the raw materials for making ropes, arrive at the factory in bales which are opened and loosened. The fibres are then spread on to a conveyor belt (Fig. 1) where they are lubricated by batching oil before being scutched. Scutching, which is a combing process, is done three times to produce a sliver which is passed through the drawing frames where it is drawn out and combed again ready for spinning (Fig. 2). The 'groomed' hemp, as it is called, is then spun into thread which is collected on bobbins (Fig. 3). It is then passed to the rope makers who do the forming and laying in a rope walk (Fig. 4).

Populations and Methods of Study

The processes of opening, spreading, scutching, drawing, and spinning, which precede the actual rope making, are undertaken by women who, with the exception of spreaders, frequently interchange jobs. Spreading is a more skilled job and is done by a select few. The women work in two separate rooms, spending a month at a time in each. Manila, sisal, and St. Helena hemp are processed in one room and sisal on its own in the other, but at the time of the survey manila was not being used. Forming and laying are done entirely by men. Of the 46 men and 42 women employed in the ropery, 82 (93%) were included in the survey; six of the men worked in all departments doing general maintenance. Of the five men and one woman who were not seen, one man refused and the rest were absent during the investigation.

The age distribution of the women differed considerably from that of the men. Of the women, 95% were aged 35 years or over compared with 38% of the males, many of whom were yard boys and apprentices aged 15 to 19 (Table 2).

TABLE 2
AGE DISTRIBUTION OF MALE AND FEMALE ROPE WORKERS

Age (years)	Males		Females	
	No.	%	No.	%
15-	16	39.0	—	—
20-	5	12.2	1	2.4
25-	4	9.8	1	2.4
35-	8	19.5	11	26.9
45-	1	2.4	13	31.7
55-69	7	17.1	15	36.6
Total	41	100.0	41	100.0

Respiratory Symptoms.—Past history of chest diseases, respiratory symptoms, and smoking habits were recorded for each worker using the standardized questions in a Medical Research Council questionnaire on chronic bronchitis (Medical Research Council, 1960). The questionnaire was extended to include questions for detecting and grading byssinosis (Lammers, Schilling, and Walford, 1964).

Respiratory Function Tests.—The forced expiratory volume over one second (F.E.V._{1.0}) was measured with a spirometer and timer. One set of measurements was taken for every worker at the first interview. Two further sets of measurements were taken at the beginning and end of the shift, which lasted from 7.00 a.m. to 4.00 p.m. The general procedure was similar to that used and described in

FIG. 1.—Spreading fibres on to the conveyor belt.

FIG. 2.—Drawing and combing fibres to produce slivers for spinning.

FIG. 3.—Spinning hemp fibres.

FIG. 4.—Rope making: forming and laying in the rope walk.

previous investigations (McKerrow, McDermott, Gilson, and Schilling, 1958).

Dust Sampling.—The airborne dust in the work rooms was sampled during the whole eight-hour shift in the areas in which workers were employed to obtain a gravimetric measure of dust concentration.

The method of sampling, using a modified Hexhlet apparatus, has been fully described in previous investigations (Roach and Schilling, 1960). It gives three sized components, coarse, medium, and fine; the coarse fraction is retained on the 2 mm. gauze in front of the filter paper; the medium and fine together is the dust which collects on the filter paper behind the gauze; and the fine is the dust which collects on a filter paper in front of which is a horizontal elutriator which excludes all particles more than 7.1μ equivalent diameter. The weight of medium dust is obtained by difference.

Results

Dust Concentrations.—In the rope walk where the men are employed, and around the draw frames and spinning machines operated by the women, there is negligible exposure to dust. However, dust concentrations around the opening, spreading, and scutching machines are quite substantial, the total

dust ranging from 0.14 to 4.51 mg./m.³ with a mean of 2.13 mg./m.³ (Table 3). Concentrations measured during the processing of St. Helena hemp were similar to those obtained when sisal was being used.

Chest Symptoms.—No worker gave a history of the characteristic symptoms of byssinosis. Nine women, however, complained of chest tightness associated with their work but not specifically on Mondays. None of the men had this complaint. Undue breathlessness on exertion and persistent cough or phlegm were also more common among the women. Although the women were older than the men, the mean length of service in the rope works was similar for both sexes, and slightly more men than women smoked (Table 4).

Lung Function Tests.—The forced expiratory volume (F.E.V._{1.0}) of the women fell during the shift; for the men it was slightly raised (Table 5). This difference between the men and women was statistically significant ($P < 0.05$), even when males aged 15 to 19 years were excluded.

Among the women, the openers, spreaders, and scutchers had a greater mean reduction in F.E.V. during the shift than the drawers and spinners, but this was found to be mainly due to the greater reduction among the nine openers, spreaders, and

TABLE 3
MEAN DUST CONCENTRATIONS IN THE ROPERY

Work Place	No. of Samples	Dust Concentration (mg./m. ³)							
		Fine		Medium		Coarse*		Total	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
Opening, spreading, and scutching	18	0.53	0.01-1.46	1.60	0.13-3.67	0.01	0.0-0.21	2.13	0.14-4.51
Draw frames and spinning	15	0.12	0.02-0.36	0.39	0.17-0.76	0.08	0.0-0.40	0.59	0.23-1.10
Rope walk	5	0.10	0.02-0.21	0.42	0.09-0.79	0	—	0.52	0.11-1.00

*There was a measurable quantity of dust on the gauze in only five of the 38 samples taken.

TABLE 4
RESPIRATORY SYMPTOMS OF MALE AND FEMALE WORKERS

	All Workers			Workers with								
	No. of Workers	Mean Age	Mean Duration of Service (years)	Cough and/or Phlegm			Chest Tightness associated with Work			Dyspnoea*		
				No. of Workers	Mean Age	Mean Duration of Service (years)	No. of Workers	Mean Age	Mean Duration of Service (years)	No. of Workers	Mean Age	Mean Duration of Service (years)
Men												
Non and ex-smokers	13	35	10	0	—	—	0	—	—	2	55	15
Smokers	28	29	9	7	29	10	0	—	—	1	19	4
All workers	41	31	9	7	29	10	0	—	—	3	43	11
Women												
Non and ex-smokers	17	48	8	2	44	6	4	46	9	5	47	5
Smokers	24	51	11	7	46	11	5	58	15	8	49	10
All workers	41	49	10	9	46	10	9	53	12	13	48	8

*Shortness of breath when walking with others at an ordinary pace on the level.

TABLE 5

INITIAL F.E.V._{1.0} AND MEAN CHANGE DURING THE SHIFT BY OCCUPATION

Occupation	No. of Workers*	Mean Age (years)	Mean F.E.V. _{1.0} (l.)	
			Initial Reading	Change During Shift
Rope makers	36 (M)	32	3.14	+0.04
Preparers and spinners	38 (F)	50	1.92	-0.05

*Three rope makers did not complete the lung function tests; two others were excluded as they had spent some time in the preparing rooms; three women were absent during the lung function tests.

Difference in mean change in F.E.V._{1.0} between rope makers and preparers and spinners is statistically significant.

$t = 2.31, p < 0.05$

scutchers who had been working in the room in which they were exposed almost entirely to St. Helena hemp. Women similarly employed but working in the other room, exposed only to sisal, showed a small reduction in F.E.V. only slightly greater than that of the drawers and spinners (Table 6). The differences between the occupational groups and between types of dust exposure were not statistically significant ($p > 0.05$), nor was there any significant interaction between occupation and type of dust, but with such small groups it would be difficult to detect a real difference unless it were very large.

Therefore, since there was some evidence that the fall in ventilatory capacity during the shift was related to exposure to St. Helena hemp dust, it seemed reasonable to suspect that the greater prevalence of chest symptoms among the women, and the reduction in the ventilatory capacity during the shift, might be due to exposure to higher levels of dust. However, the fact that the men were on the average 18 years younger than the women could not be disregarded when considering the prevalence of respiratory symptoms. Yet standardization for age would not have been satisfactory with such small numbers and dissimilar age distributions. In an attempt to elucidate the effects of exposure to the dust or hard fibre hems two further studies were made.

Chest Symptoms and Ventilatory Capacities of Other Women Workers in the Dockyard.—A random sample of 41 women, of similar age to the 41 female rope workers, was chosen from other parts of the dockyard as a control group. Most of them were cleaners, but some were packing stores or stacking wood. The two groups were compared for the prevalence of chest symptoms and F.E.V. but it was not possible to measure the change in ventilatory capacity during the shift.

Before comparing the prevalence of chest symptoms it was necessary to standardize for smoking habits, since the controls had a greater proportion of heavy smokers than the rope workers. The two groups were sub-divided into non-smokers, ex-smokers, and light, moderate, and heavy smokers, and differences in the prevalence of chest symptoms were calculated separately for each sub-group. Each difference was then weighted to allow for variation in the size of the sub-groups and the mean weighted difference was tested for significance. The proportion of workers who had chest tightness associated with their work was significantly higher ($p < 0.02$) among the rope workers than among the controls, but differences in the prevalence of other chest symptoms were not statistically significant. After adjustment for age and stem height, the mean F.E.V.s of the two groups were found to be almost identical (Table 7).

Experimental Exposures to St. Helena Hemp and its Bioactivity.—Since the ventilatory capacity changes during the shift and the symptoms of chest tightness were particularly associated with the processing of St. Helena hemp, a controlled experiment was carried out to test the effects of exposure to the dust of this hemp. Six volunteers from the staff of the London School of Hygiene and Tropical Medicine spent two periods of four hours in a dust chamber. During one period they were exposed to hemp dust at concentrations similar to those found in the rope works near the openers, spreaders, and scutchers; during the other there was no exposure. They were not told on which occasion they would be

TABLE 6

CHANGES IN F.E.V._{1.0} DURING THE SHIFT AMONG WOMEN WORKERS EXPOSED TO ST. HELENA HEMP AND SISAL

Type of Exposure	Opening, Spreading, Scutching				Drawing and Spinning			
	No. of Workers	Mean Age	Mean F.E.V. (l.)		No. of Workers	Mean Age	Mean F.E.V. (l.)	
			Initial Reading	Change during Shift			Initial Reading	Change during Shift
St. Helena hemp and sisal	9	50	2.00	-0.13	13	50	2.01	-0.02
Sisal	5	48	1.51	-0.04	11	50	1.95	-0.03

TABLE 7

RESPIRATORY SYMPTOMS AND MEAN F.E.V._{1.0} ADJUSTED FOR AGE AND STEM HEIGHT, FOR WOMEN ROPE WORKERS AND OTHER WOMEN DOCKYARD WORKERS

	Total No. of Workers	Respiratory Symptoms			F.E.V. (l.)	
		No. of Workers with			Total No. of Workers*	Mean F.E.V. _{1.0} Adjusted for Age and Stem Height†
		Cough and/or Phlegm	Chest Tightness associated with Work	Dyspnoea		
Women rope workers						
Non and ex-smokers	17	2	4	5	15	1.83
Smokers	24	7	5	8	21	1.72
All workers	41	9	9	13	36	1.77
Other women dockyard workers						
Non and ex-smokers	16	0	1	8	15	1.97
Smokers	25	7	0	12	25	1.67
All workers	41	7	1	20	40	1.78

*To avoid biased comparisons the F.E.V.s of the rope workers were repeated at the same time as the other women workers were tested: five rope workers were absent on this occasion and one of the other workers gave unreliable readings.

†Expected values for age 49.5 years and stem height 32 in. derived from the regression equation $Y = a - 0.025X_1 + 0.047X_2$, where Y = F.E.V._{1.0}, 'a' is a constant, X_1 = age, and X_2 = stem height (in.).

exposed to dust. Chest symptoms, changes in forced expiratory volume (F.E.V._{0.75}) and in airways resistance measured by body plethysmograph were recorded on both occasions. Exposure to St. Helena hemp produced symptoms of chest tightness and cough in two subjects and also a small reduction in F.E.V. and an increase in airways resistance. But statistically these changes were not significantly different from those found under control conditions (Table 8).

A sample of St. Helena hemp dust assayed on guinea-pig ileum had only a small degree of contractor activity equivalent to 0.05 µg. histamine/g. dust. This is much below the level of contractor activity found in dusts that cause byssinosis. Comparative figures for cotton and flax dusts range between 2 and 3.6 µ histamine/g. (Nicholls, 1962). It has yet to be proved that this smooth muscle contractor activity of dust is the cause of byssinosis but, at present, it appears to be a useful

index of potency (Skidmore and Nicholls, 1965).

Discussion

There is no evidence from this survey that St. Helena and sisal hems cause symptoms of byssinosis; this agrees with the findings of previous studies of sisal workers in Kenya by Stott (1958) and Gilson and others (1962), and of a contemporary survey by McKerrow, Gilson, Schilling, and Skidmore (1965) also reported in this journal.

In a previous experiment, volunteers who were exposed to cotton dust concentrations of 1.8 mg./m.³ total dust and 0.75 mg./m.³ fine dust had chest tightness and marked reductions in F.E.V._{0.75} (McKerrow, Roach, Gilson, and Schilling, 1962). Among rope workers engaged in the dustiest processes, a mean reduction in F.E.V._{1.0} of 0.13 l. was shown during the shift by nine women exposed mainly to the dust of St. Helena hemp, the hard fibre with which chest symptoms are most commonly associated. At the levels of dust to which they were exposed a greater reduction in ventilatory capacity would have been expected if the dust of St. Helena hemp can cause byssinosis.

However, the dust of the hard hems, particularly St. Helena hemp, may cause chest tightness associated with a small change in ventilatory capacity during the work shift. Comparison of the ventilatory capacities of the rope workers with those of others employed in the same dockyard suggests that although such dusts may not cause permanent ill-effects on respiratory function, they are irritant and should be controlled to levels which do not exceed about 2 mg./m.³ of total dust. This is a tentative figure based on the evidence of this survey.

TABLE 8

RESULTS OF LUNG FUNCTION TESTS ON SIX VOLUNTEERS EXPOSED TO ST. HELENA HEMP DUST: MEAN INITIAL READING AND MEAN CHANGE AFTER EXPOSURE

	Control Conditions		Hemp Dust	
	Mean Initial Reading	Mean Change	Mean Initial Reading	Mean Change
F.E.V. _{0.75} (l.)	3.92	-0.03	4.00	-0.12
Airway resistance (cm. H ₂ O/l./sec.)	1.11	-0.10	0.85	+0.20
Mean dust concentrations (mg./m. ³)				
Total	0.34		1.85	
Fine	0.11		0.75	

There are no statistically significant differences between the mean changes in F.E.V. and airway resistance after exposure to St. Helena hemp and the mean changes after no dust exposure.

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