Dust exposure in manual flax processing in Egypt¹

MADBULI H. NOWEIR, YASSIN M. EL-SADIK, ABDEL-AZIZ EL-DAKHAKHNY, and HASSAN A. OSMAN

Occupational Health Department, High Institute of Public Health, University of Alexandria, Egypt

Noweir, M. H., El-Sadik, Y. M., El-Dakhakhny, A-A., and Osman, H. A. (1975). *British Journal of Industrial Medicine*, 32, 147-154. Dust exposure in manual flax processing in Egypt. Manual flax processing originated in Egypt in 2 000 BC. In the present study a representative sample of the workers involved in this trade, where flax is processed in small workshops or homes, was examined, and their dust exposure was evaluated. The study showed that workers handling and processing flax are exposed to high concentrations of dust; the levels of dust at hackling and combing are considerably higher than at batting and spinning. Byssinosis prevailed in 22.9% of the examined workers, and 18.4% of them had their forced expiratory volume in one second reduced by more than 10% at the end of the first morning work period (4 hours) of the week. Both the rates and the grades of these syndromes increased with duration of exposure. Smoking appeared to be one of the important contributory factors in the production of byssinosis. The relationship between dust concentration and prevalence of byssinosis seems to be curvilinear.

Manual processing of flax is a very old industry which existed in Ancient Egypt. Picture writing describing flax cultivation and processing is present in most graves of Bershia (2 000 BC) and Luxor (1 600 BC) (Ibrahim, 1959; Erman and Ranke, 1945).

Processing has not changed much since that date. After drying and deseeding in the field, flax is biologically 'retted', a process in which the fibres are loosened from the woody parts of the plant by a putrefactive process. This is conducted outdoors in concrete containers in which flax bundles are put in layers, covered with water, and left until 'ripened'; this process requires one or two weeks, depending on the ambient temperature. The dry retted flax is beaten with a heavy piece of timber to break out the wooden parts, hackled to clean out these parts, and then combed to remove short staples. Spinning is conducted using a primitive spin that is usually

operated by a young worker, while the fibres are fed and spun by an experienced spinner. Figure 1 shows these different operations.

For historical, economic, and ecological reasons the processing of flax in Egypt has become concentrated mainly in a small town called Menuf (mostly manual) and in a village called Shubra-Melles (mostly mechanical); both are located in the Nile Delta. Processing is also conducted in a few other places in Lower Egypt but to a considerably lesser extent.

Exposure to dust in the handling and processing of flax has been known to cause byssinosis in some exposed workers similar to cotton workers' byssinosis (Mair *et al.*, 1960; Smiley, 1961; Bouhuys, van Duyn, and van Lennep, 1961; Smith *et al.*, 1962; Bouhuys, Hartogensis, and Korfage, 1963; Elwood, 1965; Elwood *et al.*, 1965, 1966) despite the fact that the fibres of flax and cotton, from which the dust originates, are botanically quite different and stem

¹Supported by USPHS PL-480 Project No. 03-001-3

FIG. 1. The manual processing of flax in Menuf, Egypt, 1974: (A) batting; (B) hackling; (C) combing; (D) spinning.

from different parts of the plant. It was suggested that the responsible agent(s) in the flax dust originated as a metabolic product of bacteria and fungi during flax retting (Bouhuys *et al.*, 1961).

In an epidemiological study on workers processing flax in the village of Shubra-Melles, El Batawi and Hussein (1964) found that out of 27 workers who had been involved in manual flax processing, 25 subjects suffered from byssinosis. Manual flax processing has, however, been concentrated in the town of Menuf. Many inhabitants have been involved in this occupation since their childhood and for many generations. It was expected, in view of the above reports, that respiratory diseases would prevail among them at high rates. The present

study was therefore conducted with the following objectives

(1) to examine the respiratory health conditions of workers in manual flax processing, and

(2) to determine the relationship of environmental conditions and dust concentrations to the prevalence of respiratory disorders.

The results of this investigation are also needed by the local health authorities to help in planning occupational, social, and health services for these workers.

The number of flax workers in this town has been estimated by the local employment office to be slightly higher than 1 600 (including business owners). Most of them are employed in small workshops, which usually include from eight to 30 men and children, while a few work in their homes. They usually work a morning period of 4-5 hours, break for 2-3 hours for lunch and a short sleep, and then resume work in the afternoon for 3-4 hours. Workers involved in batting and hackling usually work outdoors in front of the shop or the home, while those combing and spinning the fibres work indoors. All workplaces have poor hygienic conditions.

Methods

Dust measurement and analysis

Airborne dust was sampled in six workshops that represent the different sizes and localities of the 56 shops in town. Total and respirable dust samples were taken at the breathing levels of workers and beside each operation.

Total dust was collected by a Unico-550 turbine-jet high-volume sampler (Fall River, Massachusetts, USA). Respirable dust was collected, as described by Roach and Schilling (1960), using a Casella air-sampling hexhlet instrument (London, England) modified to carry filter discs for collecting the dust. The rate of flow was kept constant at 50 l/min for the hexhlet sampler, and the sampling was conducted for a period of 30 minutes by both samplers. The filter discs used in both instruments were 10 cm glass fibre (Reeve Angel, Clifton, New Jersey, USA). The discs were prepared in a desiccator under vacuum for 24 hours and weighed before and after sampling. A total of six pairs of samples were collected at each operation.

Each filter disc with either the total or respirable dust was divided exactly into two halves, and each half was analysed for either protein or carbohydrates. Protein was determined using the micro-Kjeldahl method modified for fibreglass filter samples by Goppers and Paulus (1961). 'Soluble carbohydrates' were extracted by soaking the filter (with the dust sample) in 20 ml redistilled water in a 50 ml centrifuge tube and stirring with a glass rod. The tube was left overnight in a refrigerator and then centrifuged, and the supernatant fluid was analysed for carbohydrates as described by Morris (1948). The sediment was re-suspended in 15 ml water, mixed with 5 ml amylase solution containing 0.02 mg (about 10 EU/mg),

incubated for 30 minutes at 37°C, and then centrifuged, and the 'insoluble carbohydrates' were determined in the supernatant by the same method.

Medical examination

Fourteen workshops, including those which had been environmentally surveyed, were randomly selected, and the workers employed there ($n = 406$) were examined. A control group of agricultural workers ($n = 100$) with distributions of age, anthropological measurements, social and ecological backgrounds, and smoking habits similar to those of the examined workers, but with no history of dust exposure, were selected from the same town and examined.

Social, personal, occupational, and past medical histories, with special emphasis on respiratory and allergic diseases and smoking habits, were recorded for each subject. A questionnaire on chest symptoms based on experience from studies of byssinosis in Egypt and on the questionnaire used by Roach and Schilling (1960) was completed. This was followed by a complete medical examination of each subject.

Byssinosis was diagnosed and graded as recommended by the Sub-committee on Respiratory Diseases in Textile Workers of the Permanent Commission and International Association on Occupational Health (Schilling *et al.*, 1964).

Subjects complaining of chronic or recurrent cough and phlegm on most days for at least three months per year for two successive years were diagnosed as chronic bronchitis, provided no localized diseases of the lungs, bronchi, and upper respiratory tract or cardiovascular cause were present (Fletcher, 1959). Subjects with a present history of recurrent attacks of paroxysmal dyspnoea accompanied by wheezing and relieved by antispasmodics were diagnosed as bronchial asthma (Hinshaw and Garland, 1963).

Ventilatory function changes

The examined workers were divided into eight groups according to the locality of their shops, and ventilatory function measurements were conducted for each group, in a central place, on Sunday (the first day of the week after a Saturday weekend which is market day) for eight consecutive Sundays. Timed forced expiratory volume ($FEV_{1.0}$) was measured for each worker before starting work (7–8 am) and immediately after the end of the morning work period (12–1 pm), i.e., 4–5 hours' exposure. Ventilatory function for the control subjects was similarly measured in the morning and five hours later on the same day as the medical examination. Measurements were taken with a Godart type PM pulmometer (Utrecht, Holland). Five blows, after a maximal inspiration, were performed by the examined subject, and the average of the last three values was taken as the result of each test. Subjects showing a variation in the last three readings of more than 5% were considered uncooperative and their results were rejected. The percentage reduction (or increase) in $FEV_{1.0}$ of the afternoon value from that of the morning value was computed for each worker. Those who had a decrement in $FEV_{1.0}$ of 10% or more were treated as if they had byssinosis (National Conference on Cotton Dust and Health, 1971).

The data were statistically analysed using a standard t test or χ^2 test.

Results

No significant differences were found between the different shops relative to dust concentration in air, nature of collected dust, or the health of the workers. Consequently, data collected from these shops (or homes) were combined and are presented in the tables.

Table 1 presents total and respirable atmospheric dust concentrations for the different operations. Concentrations of dust produced in hackling and combing were much higher than those in batting which are relatively higher than in spinning.

TABLE 1
CONCENTRATION OF AIRBORNE DUST DURING
THE DIFFERENT OPERATIONS

Operation	Concentration (mg/m^3)			
	Total dust		Respirable dust	
	Mean	SD	Mean	SD
Batting	17.40	1.80	2.98	0.61
Hackling	54.67	10.50	9.75	1.55
Combing	67.35	10.42	8.55	1.48
Spinning	8.54	1.26	1.54	0.65

Protein and carbohydrate (soluble) contents in the total and respirable dust samples are presented in Table 2. No significant differences between these constituents were observed in the dust collected during the different operations. However, these constituents were slightly lower in the dust collected during spinning than in the dust collected during the other operations. Protein was slightly lower in the respirable dust than in the total dust while the carbohydrate fraction was slightly higher in the respirable than in the total dust. No carbohydrates (insoluble) could be detected in the amylase-treated extract of any sample.

Table 3 presents the prevalence of byssinosis, chronic bronchitis, and bronchial asthma among the examined workers as well as the control subjects. Like the experience of El Batawi and Hussein (1964) the symptomatology of the flax workers was more obvious and the diagnosis was easier to make than in cotton workers. Byssinosis was diagnosed in 22.9% of the examined workers. The prevalence was maximum among the workers who had been exposed for a period ranging from 20 to 30 years (33.7%) and was slightly decreased among those exposed for more than 30 years (29.8%). Chronic bronchitis (17.5%) and bronchial asthma (11.8%) were significantly higher ($P < 0.05$) among the exposed workers than among the control subjects. It has been observed that

TABLE 2
PROTEIN AND CARBOHYDRATE CONTENTS IN AIRBORNE DUST DURING THE DIFFERENT OPERATIONS

Operation	Percent dry dust							
	Total dust				Respirable dust			
	Protein		Carbohydrate		Protein		Carbohydrate	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Batting	9.8	0.50	0.58	0.08	7.4	1.50	0.68	0.20
Hackling	9.3	0.78	0.60	0.10	8.0	1.84	0.63	0.18
Combing	9.8	0.37	0.58	0.05	6.7	1.95	0.66	0.14
Spinning	8.3	0.49	0.51	0.07	6.2	1.60	0.60	0.16

TABLE 3
PREVALENCE OF RESPIRATORY DISEASES AMONG EXAMINED WORKERS

Exposure (years)	No. examined	Age (years)		Byssinosis grade						Total byssinosis		Chronic bronchitis		Bronchial asthma	
		Mean	SD	I		II		III		No.	%	No.	%	No.	%
				No.	%	No.	%	No.	%						
0—	147	22.6	7.6	16	10.8	7	4.8	—	0	23	15.6	18	12.2	5	3.4
10—	103	31.8	8.6	3	2.9	15	14.5	2	1.9	20	19.4	19	18.4	10	9.7
20—	89	41.3	7.6	3	3.4	22	24.7	5	5.6	30	33.7	16	18.0	14	15.7
30+	67	54.3	7.7	—	0	10	14.9	10	14.9	20	29.8	18	26.7	19	28.4
Total	406	34.5	17.3	22	5.4	54	13.3	17	4.2	93	22.9	71	17.5	48	11.8
Control	100	33.4	13.2	—	0	—	0	—	0	—	0	8	8.0	2	2.0

TABLE 4
REDUCTION IN FEV_{1.0} DURING THE FIRST MORNING OF THE WORKING WEEK AMONG EXAMINED WORKERS

Exposure (years)	No. examined	Age (years)		Percent reduction in FEV							
		Mean	SD	10—20		20+		Total			
				No.	%	No.	%	No.		%	
0—	119	21.3	7.2	9	7.5	3	2.5	12	10.0		
10—	83	30.3	8.5	7	8.4	5	6.1	12	14.5		
20—	62	40.1	7.8	10	16.1	8	12.9	18	29.0		
30+	44	52.6	7.5	8	18.2	7	15.9	15	34.1		
Total	308	32.0	16.1	34	11.0	23	7.4	57	18.4		

workers with longer exposure have a more advanced degree of byssinosis, and those with a milder degree have had less exposure. The prevalence of chronic bronchitis and bronchial asthma increased also among workers of advanced age and longer exposure; the increase of bronchial asthma was more consistent than that of chronic bronchitis.

Table 4 presents the prevalence of workers' reduction in FEV_{1.0} at the end of the first morning work period (4-5 hours) of the week. Some workers did not attend for pulmonary function measurements while others were considered uncooperative and their results were rejected. The number (percent) of workers showing a reduction in FEV_{1.0} of more

TABLE 5
EFFECT OF SMOKING ON PREVALENCE OF BYSSINOSIS AND REDUCTION IN FEV_{1.0}

Diagnosis	Smokers			Non-smokers		
	Exposure (years)		Number/total examined	Exposure (years)		Number/total examined
	Mean	SD		Mean	SD	
Byssinosis (subjective)	29.6	9.8	62/210 (29.5%)	32.6	10.6	31/196 (15.8%)
10% Reduction in FEV _{1.0}	32.1	10.8	43/154 (24.8%)	35.7	11.2	14/154- (9.1%)

TABLE 6
PREVALENCE OF BYSSINOSIS AMONG EXAMINED WORKERS IN THE DIFFERENT OPERATIONS

Operation	Number examined	Age (years)		Exposure (years)		Byssinosis	
		Mean	SD	Mean	SD	No.	%
Batting	50	36.6	11.7	24.6	10.8	15	30.0
Hackling and combing	19	32.6	12.3	21.9	10.2	7	37.0
Spinning	337	34.3	15.2	20.7	14.6	71	21.0
Total	406	34.5	17.3	20.9	16.1	93	22.9

TABLE 7
REDUCTION IN FEV_{1.0} AMONG EXAMINED WORKERS IN THE DIFFERENT OPERATIONS

Operation	Number examined	Age (years)		Exposure (years)		FEV _{1.0} Reduction > 10%	
		Mean	SD	Mean	SD	No.	%
Batting	40	36.9	11.1	24.8	10.9	10	25.0
Hackling and combing	7	43.2	10.3	31.6	9.8	4	57.1
Spinning	261	32.7	14.6	20.1	13.9	43	16.5
Total	308	32.0	16.1	21.1	16.0	57	18.4

than 10% increased with exposure. Workers with longer exposure showed higher decrements than those who had less exposure. No reduction in FEV_{1.0} of more than 10% was observed among the control subjects.

The effect of smoking on the prevalence of byssinosis and reduction in FEV_{1.0} among examined workers is shown in Table 5. Byssinosis as well as reduction in FEV_{1.0} prevailed at significantly higher rates ($p < 0.01$) among smokers than non-smokers. A great number of the smokers (46%) used to smoke five to 10 cigarettes per day while some (24%) smoked less than five cigarettes per day, and a few (12%) smoked 'sweetened tobacco' (tobacco treated with molasses and smoked through a water filter).

Tables 6 and 7 illustrate the prevalence of byssinosis and reduction in FEV_{1.0} among the examined workers according to the type of operation in which they had been involved, i.e., according to the dust concentrations to which they had been exposed. Hackling and combing workers were combined in one group because of their small number and because the dust concentrations to which they had been exposed were relatively close. The prevalence of byssinosis, as well as the reduction in FEV_{1.0}, was highest in workers exposed to relatively high concentrations of dust.

Discussion

This study shows that workers handling and

processing flax in the manual operations are exposed to high concentrations of dust (Table 1). Dust concentrations during hackling and combing are considerably higher than during the other two operations. Hackling has long been known to be the most dangerous operation in flax processing. Ramazzini (1705) wrote '... those who hackle the flax and hemp to prepare it for being spun and wove, afford frequent instances of the unwholesomeness of their trades...'. d'Evelyn (1894) reported 'hackling is the most deadly process... the hacklers all die young and all suffer from chronic diseases of the lung caused by flax dust'. In hackling, bundles of beaten flax are hit violently with a racket to remove the wooden parts of the plant from the fibres. In combing, bundles of hackled flax are inspected and short fibres are combed out of it through steel nail combs. Flax bundles are turned around and spread out several times in both operations; those movements produce a considerable amount of dust especially near the worker's face.

The proportions of respirable to total dust collected during the different operations were consistent (17.2–18.3%) except for combing where this proportion was lower (12.8%). This may be attributed to the fact that more flax staples ($> 7 \mu$) fly from this operation which contributes to the increase of the nonrespirable fraction in the airborne dust.

No threshold limit value (TLV) is yet available for flax dust. Studies are now in progress to develop such value(s) (Noweir *et al.*, in preparation). However, the seriousness of workers' exposure to the levels of dust reported in this study might be evaluated by comparing such levels with the TLV of cotton dust. Flax and cotton dusts have been known to be closely related in their effect (Werner, 1955; Mair *et al.*, 1960; Bouhuys *et al.*, 1961). The TLV for cotton dust has been listed in the 'Notice of Intended Changes' as 0.2 mg/m^3 —lint-free as determined by vertical elutriator—(American Conference of Government Industrial Hygienists, 1972).

As a consequence of exposure to the above indicated concentrations of dust, respiratory complaints and symptoms occurred among exposed workers. Twenty-three percent of the exposed workers were reported byssinotics with different grades. Unlike the experience of Mair *et al.* (1960), the prevalence of byssinosis among exposed workers was mostly related to the duration of exposure to the dust, except for workers exposed for relatively longer periods (e.g. 30 years and more). This might be due to the fact that some of the workers who develop byssinosis leave the work, especially in the older age groups. The increase in the degree of the disease according to the duration of exposure also may lead to the conclusion that the different grades of byssinosis succeed each other in diseased subjects.

The significantly higher prevalence of chronic bronchitis and bronchial asthma among workers than among the controls may be logically attributed to exposure to flax dust. This is supported by previous reports; e.g., Bouhuys *et al.* (1961) reported that after many years of exposure to vegetable dust, including flax dust, the clinical findings may be indistinguishable from those in chronic pulmonary insufficiency from other factors. However, the reported increase in the prevalence of these diseases according to age and duration of exposure to the dust may be inconsistent with the previous findings of Ferris, Anderson, and Burgess (1962) among some of the flax workers in the USA.

The fall in FEV_{1.0} during the Sunday morning's work period in workers exposed to dust demonstrates the importance of such a test in detecting affected subjects. The number of workers showing a reduction in FEV_{1.0} of more than 10% (18.4%) was less than those reported as byssinotics on the basis of history (22.9%); however, the difference was not significant. This criterion (*viz.*, reduction in FEV_{1.0} of more than 10%) has been proposed for a minimum exposure of six hours. The FEV_{1.0} was measured for the workers in this study at the end of a work period of about four hours, and this shorter exposure period may explain the apparently low prevalence of this sign.

Cigarette smoking appeared to be one of the important contributory factors in the production of byssinosis among exposed workers (Table 5). Data presented in this study indicate that smoking increases the worker's risk of byssinosis and confirm previous investigations (Carey *et al.*, 1965; Bouhuys *et al.*, 1969; Zuskin *et al.*, 1969; Merchant *et al.*, 1972). Zuskin, however, found that smoking did not affect the worker's reduction in FEV_{1.0} on the first work day of the week. It may be noted that workers stated that smoking helps the expectoration of sputum and, consequently, releases chest tightness during work; this needs more detailed investigation.

The protein in cotton dust has been shown to be the constituent most highly correlated with the prevalence of byssinosis among workers exposed to this dust (Roach and Schilling, 1960). The carbohydrates in cotton and flax dust have also been suggested as being at least partially responsible for causing the byssinosis syndrome among some of the exposed workers (Cavagna and Finulli, 1962; Noweir, 1971). Consequently, both constituents (protein and carbohydrates) were determined in the collected dust samples as indices of the 'active' organic fraction in the dust which might in some way indicate the content of the active agent(s). Neither protein nor carbohydrate fractions showed significant variations in the dust collected during the different operations. Also, no significant difference was observed in the concentration of these con-

FIG. 2. Relationship between occupation, dust levels, byssinotic symptoms, and fall in FEV_{1.0}. The frequency of both byssinotic symptoms and reduction in FEV_{1.0} increased with increasing dust levels. The relationship is curvilinear in that at higher levels of dust increases do not produce as great an effect on symptoms or FEV_{1.0} as increases at a lower level.

stituents in total and respirable dust. As a consequence of this similarity, dust concentrations could be safely correlated with the prevalence of byssinosis and the reduction in FEV_{1.0} among workers during the different operations (Figure 2). The number of hacklers and combers who had their FEV_{1.0} measured in this study was too small (7 workers) for the results to be presented in the figure. The relation of the mean concentrations of either total or respirable dust to the prevalence of byssinosis among examined workers appears to be curvilinear. Roach and Schilling (1960) and Schilling and Roach (1961) found that such a relation between the prevalence of byssinosis and the concentrations of total or 'fine' dust is linear at low levels of exposure. The maximum mean dust concentrations in their investigations were 6 mg/m³ for total dust and 0.5 mg/m³ for 'fine' dust. However, byssinosis prevailed at considerably higher rates among the workers examined by these authors than among those examined in the present study. Many factors may be responsible for this, e.g., the difference in the physical and chemical qualities of the dust, the difference in exposed populations, the probable presence of other factors such as air pollution that may have contributed to the incidence of respiratory diseases among those examined in the previous studies. The role of these factors will be considered in a discussion of the development of the TLV for flax dust (Noweir *et al.*, in preparation).

References

- American Conference of Government Industrial Hygienists. Threshold Limit Committee (1972). *Threshold Limit Values*. ACGIH, Cincinnati, Ohio, USA.
- El Batawi, M. A. and Hussein, M. (1964). Endemic byssinosis in an Egyptian village. *British Journal of Industrial Medicine*, **21**, 231-234.
- Bouhuys, A., van Duyn, J., and van Lennep, H. J. (1961). Byssinosis in flax workers. *Archives of Environmental Health*, **3**, 499-509.
- , Hartogensis, F., and Korfage, H. J. H. (1963). Byssinosis prevalence and flax processing. *British Journal of Industrial Medicine*, **20**, 320-323.
- , Wolfson, R. L., Horner, D. W., Brain, J., and Zuskin, E. (1969). Byssinosis in cotton textile workers. Respiratory survey of a mill with rapid labor turnover. *Annals of Internal Medicine*, **71**, 257-269.
- Carey, G. C. R., Merrett, J. D., Elwood, P. C., Pemberton, J., and McAulay, I. R. (1965). Ventilatory capacity in flax workers in Northern Ireland. *British Journal of Industrial Medicine*, **22**, 109-120.
- Cavagna, G. and Finulli, M. (1962). Il contenuto di endotossine batteriche nella polvere di cotone, lino e canapa. (The bacterial endotoxin content in cotton, flax and hemp dusts.) *Medicina del Lavoro*, **53**, 696-704.
- d'Evelyn, A. (1894). In Osborn, E. H. Reports by the Inspector of Factories upon the conditions of work in flax mills and linen factories in the United Kingdom. *Parliamentary Papers* 94, Vol. VIII, C. 7287. HMSO, London.
- Elwood, P. C. (1965). Respiratory symptoms in men who had previously worked in a flax mill in Northern Ireland. *British Journal of Industrial Medicine*, **22**, 38-42.
- , McAulay, I. R., McLarin, R. H., Pemberton, J., Carey, G. C. R., and Merrett, J. D. (1966). Prevalence of byssinosis and dust levels in flax preparers in Northern Ireland. *British Journal of Industrial Medicine*, **23**, 188-193.
- , Pemberton, J., Merrett, J. D., Carey, G. C. R., and McAulay, I. R. (1965). Byssinosis and other respiratory symptoms in flax workers in Northern Ireland. *British Journal of Industrial Medicine*, **22**, 27-37.
- Erman, A. and Ranke, H. (1945). *Ägypten und ägyptische Leben*, p. 518. Arabic translation by A. Abu-Bakr and Kamal. Egyptian Nahda Publishing Company, Cairo, Egypt.
- Ferris, B. G., Jr., Anderson, D. O., and Burgess, W. A. (1962). Prevalence of respiratory disease in a flax mill in the United States. *British Journal of Industrial Medicine*, **19**, 180-185.
- Fletcher, C. M. (1959). Chronic bronchitis. *American Review of Respiratory Diseases*, **80**, 483-494.

- Goppers, V. and Paulus, H. J. (1961). Isolation of proteins from samples of airborne particulates. *American Industrial Hygiene Association Journal*, **22**, 54-58.
- Hinshaw, H. D. and Garland, L. H. (1963). *Diseases of the Chest*, 2nd edition, p. 297. Saunders, Philadelphia.
- Ibrahim, N. M. (1959). *Egypt and Ancient Middle East-Ancient Egyptian Civilization*, p. 270. Recent Publishing Foundation, Cairo, Egypt. (in Arabic).
- Mair, A., Smith, D. H., Wilson, W. A., and Lockhart, W. (1960). Dust diseases in Dundee textile workers. *British Journal of Industrial Medicine*, **17**, 272-278.
- Merchant, J. A., Kilburn, K. H., O'Fallon, W. M., Hamilton, J. D., and Lumsden, J. C. (1972). Byssinosis and chronic bronchitis among cotton textile workers. *Annals of Internal Medicine*, **76**, 423-433.
- Morris, D. L. (1948). Quantitative determination of carbohydrates with Dreywoods anthrone reagent. *Science*, **107**, 254-255.
- National Conference on Cotton Dust and Health (1971). The status of byssinosis in the United States. Summary (1971). *Archives of Environmental Health*, **23**, 230-234.
- Noweir, M. H. (1971). Transactions of the National Conference on Cotton Dust and Health, Charlotte, NC, 1970. *Archives of Environmental Health*, **23**, 48.
- Ramazzeni, B. (1705). *A Treatise of the Diseases of Tradesmen*. Bell, London.
- Roach, S. A. and Schilling, R. S. F. (1960). A clinical and environmental study of byssinosis in the Lancashire cotton industry. *British Journal of Industrial Medicine*, **17**, 1-9.
- Schilling, R. S. F. and Roach, S. A. (1961). Safe levels of dustiness in cotton spinning mills. *Pure and Applied Chemistry*, **3**, 69-75.
- , Vigliani, E. C., Lammers, B., Valic, F., and Gilson, J. C. (1964). A report on a conference on byssinosis. *Proceedings of the XIVth International Congress of Occupational Health, Madrid, 1963*, vol. 2, pp. 137-145. Excerpta Medica Foundation, Amsterdam.
- Smiley, J. A. (1961). Background to byssinosis in Ulster. *British Journal of Industrial Medicine*, **18**, 1-9.
- Smith, D. H., Lockhart, W., Mair, A., and Wilson, W. A. (1962). Flax workers' byssinosis in East Scotland. *Scottish Medical Journal*, **7**, 201-211.
- Werner, G. C. H. (1955). De la bronchiolite oedémateuse allergique. *Archives des Maladies Professionnelles, de Médecine du Travail et de Sécurité Sociale*, **16**, 27.
- Zuskin, E., Wolfson, R. L., Harpel, G., Welborn, J. W., and Bouhuys, A. (1969). Byssinosis in carding and spinning workers. Prevalence in the cotton textile industry. *Archives of Environmental Health*, **19**, 666-673.

Received for publication 10 April, 1974.

Accepted for publication 2 August, 1974.