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Respiratory disease in cotton textile workers in the People's Republic of China

I. Respiratory symptoms

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CHRISTIANI DC, EISEN EA, WEGMAN DH, YE T-T, LU P-L, GONG Z-C, DAI H-L. Respiratory disease in cotton textile workers in the People's Republic of China: I Respiratory symptoms. *Scand J Work Environ Health* 12 (1986) 40–45. The prevalence of byssinosis and nonspecific respiratory symptoms was studied in 887 textile workers with at least two years of employment in two cotton mills and one silk mill in Shanghai, the People's Republic of China. A standardized respiratory questionnaire was used, and environmental sampling was performed with vertical elutriators and colorimeter grading. Eight percent of the cotton textile workers complained of byssinosis. The reports of byssinosis were mostly mild (grade 1/2), more prevalent among women, and unrelated to duration of employment or elutriator dust levels. Nonspecific respiratory symptoms were significantly more prevalent among cotton textile workers than silk workers. After adjustment for age, gender, and smoking in logistic regression models, the odds ratios for the effect of working in cotton textile mills on chronic bronchitis, chronic cough, and frequent chest illness were 3.3, 2.9 and 4.7, respectively. Although none of the symptoms were related to current dust levels, the range of exposures was narrow, and information was only available on current levels of cotton dust. This study represents the first respiratory survey of the textile industry in China using diagnostic criteria similar to that used in the United States and England; it defines a cohort for prospective investigation.

Key terms: byssinosis, chronic bronchitis, chronic respiratory disease, cotton dust.

The People's Republic of China is a major cotton producer (15), yet there has been only a single report from that country on the respiratory effects of cotton dust, a clinicophysiological study from Shanghai describing 21 cases of byssinosis in workers exposed to cotton dust in the yarn preparation areas of several mills (34, 35). Although there have been numerous epidemiologic studies of the acute and chronic effects of cotton dust exposure in developed countries, the literature, particularly on chronic effects under conditions of low dust exposure, remains inconclusive and controversial (2, 3, 14, 16, 20, 21, 24, 31, 33).

This study was undertaken in order to investigate further the relationship between exposure to cotton dust and chronic lung disease. The Chinese textile workers were a desirable study population because of the relatively low prevalence of cigarette smoking, particularly among women, in that country. Furthermore, the cotton in China is still hand-picked, allowing us to examine whether hand-picked cotton is associated

with less adverse health effects than cotton that is picked by machine.

The prevalence of byssinosis, chronic respiratory symptoms, and impaired pulmonary function were studied in workers from two cotton textile mills in Shanghai. Diagnostic criteria and pulmonary function equipment similar to that used in the United States and England were used so that results would be comparable to previously reported findings. This report describes the acute and chronic respiratory symptoms observed in this population. The results of the pulmonary function analysis are the subject of a separate report (6).

Subjects and methods

Study population

Workers were selected from the yarn preparation areas (opening, carding, drawing, combing, winding, and spinning) of two cotton textile mills. All the subjects were day shift workers without a history of respiratory disease before entering work in the mills and with at least two years of exposure. This population represented 60 % of all day shift workers in yarn preparation. Virtually all of the remaining 40 % were newly hired workers with less than two years' experience, as the textile industry had expanded rapidly in the postcultural revolution period. Approximately 90 % of the eligible workers were surveyed.

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Synthetic textile manufacturing workers were considered as possible referents. However, they were not studied because all of the synthetic mills in Shanghai were found to be recently converted cotton mills. Instead, silk workers in a nearby factory were chosen as a comparison population since there have been no reports of excess respiratory disease in that industry. The same exclusion criteria were used to select the reference population, as well as the exclusion of silk workers with a past history of cotton dust exposure or a current cotton dust exposure in one of the silk-cotton blending areas. These criteria resulted in approximately 60 % of all silk-mill day shift workers being eligible for testing. Of these eligible silk workers, 90 % participated in the study.

All of the cotton and silk workers lived in one of two large workingclass neighborhoods in urban Shanghai, and individual earnings in the mills were identical. Both factories were built in the 1920s and then retrofitted with their current ventilation systems in the late 1950s. Plant officials stated that production and dust control methods in yarn preparation had remained unchanged since the late 1950s.

Methods

Respiratory questionnaire. On return to work after a rest period of 48 h, and before entering the workshop, a standardized respiratory symptom questionnaire (10), modified to include questions regarding work-related symptoms, was administered to each worker. Before the study, the questionnaire was translated into Chinese and then translated back into English to verify the accuracy of the translation. An intensive training program was conducted for the Chinese physicians administering the test.

Symptoms were originally defined as follows: Bysinosis: grade 0 = no symptoms; grade 1/2 = chest tightness or shortness of breath occasionally on the first day or other days of the work week; grade 1 = chest tightness or shortness of breath consistently on the first day of the work week; grade 2 = chest tightness or shortness of breath on the first and other days of the work week (18, 31); chronic bronchitis: cough and sputum from the chest for as much as three months per year for a minimum of two consecutive years; chronic cough: cough without sputum for at least 5 d each week, not associated with a recent chest illness; acute chest illness was defined as acute cough with sputum or increased cough and sputum with or without fever.

Environmental assessment. Environmental sampling was done with vertical elutriators (General Metal Works, Inc) which are designed to collect respirable particles. With the cone-shaped elutriator, the air stream is slowly aspirated through the chamber where particles larger than 15 μ in aerodynamic diameter settle out and smaller particles (less than 15 μ) with lower falling speeds are carried upwards and deposited on

the filter. The sampler is designed, therefore, to collect only the respirable range of inhalable particles. For our sampling, the operational definition of respirable was the fraction of airborne material that passed through the precollection system designed to simulate the upper respiratory tract (7, 19, 32). Samples were taken with 5- μ polyvinyl chloride hydrophobic filters which were preweighed and then weighed again on the same balance (sensitive to 10⁻⁵ g) after the sampling.

In addition to vertical elutriator samples, bulk samples were taken from the center of 12 cotton bales and analyzed for grade. A Nickerson-Hunter cotton colorimeter was used for color grading, and trash and leaf contents were determined by electronic scanning. This method of grading is based on standards for grade of American Upland cotton. The bulk samples were not large enough for the Shirley Analyzer trash analysis.

Exposure to cotton dust was assumed to be zero for all the silk workers. Cigarette smoking was measured in units of pack-years, as well as categorically (only smokers and nonsmokers, as there were virtually no exsmokers in this population.)

Analysis. The prevalence of respiratory symptoms was first compared between the cotton and silk workers with a chi-square analysis or the Fisher's exact test. Multivariate logistic regression models were then used to evaluate the association between cotton dust exposure and each symptom, controlling for the effects of sex, age, and smoking habit.

Results

Environmental data

Ninety-six percent of the cotton was grown in China and hand-picked. An analysis of the cotton grade revealed that all samples were in the white to spotted range, with no tinged or yellowed cotton. All samples were uniform in trash content except one, which was two grades lower in leaf content. Hence, the cotton in use in these mills was generally of good grade.

The vertical elutriator dust concentrations ranged from a median of 0.45 to 1.52 mg/m³ (table 1). The highest concentrations were measured in the opening, blowing, and carding areas. The range of exposure was narrow (threefold), and the distribution of exposure was bimodal with sharp peaks. Thus, the variability

Table 1. Cotton dust levels: Vertical elutriator samples (mg/m³).

Work area	Number of samples	Mean	Median	Range
Opening	26	1.56	1.48	0.42—2.90
Blowing	7	1.41	1.07	0.59—2.32
Carding	32	1.44	1.52	0.48—2.47
Drawing	23	0.89	0.57	0.22—2.21
Combing	27	0.52	0.49	0.19—0.98
Winding	15	0.45	0.45	0.15—0.61
Fine spinning	8	0.56	0.59	0.28—0.80

Table 2. Demographic characteristics and prevalences of respiratory symptoms in cotton and silk workers. (SEM = standard error of the mean)

	Cotton workers	Silk workers
Number of subjects	448	439
Mean age (years) ± SEM	37.3 ± 0.50	35.7 ± 0.51
Work tenure (years) ± SEM	16.3 ± 0.49	16.7 ± 0.57
Percent male	47.8	42.1
Percent current smokers	33.9	23.2*
Mean amount smoked (pack-years) ± SEM	9.70 ± 10.1	9.07 ± 9.9
Symptoms (%)		
Chronic cough	19.2	6.8*
Chronic bronchitis	21.2	7.1*
Chest illness (> 1) past three years	8.3	1.6*
Byssinosis (all grades)	7.6	0

* $p < 0.001$.

Table 3. Respiratory symptoms in female cotton and silk workers.^a

Symptom	Cotton workers (N = 226)		Silk workers (N = 253)	
	N	%	N	%
Chronic cough	32	14.2	12	4.7***
Chronic bronchitis	30	13.3	14	5.5**
Chest illness (> 1) past three years	12	5.3	4	1.6*
Byssinosis				
Grades 1/2 + 1	23	10.2	—	0
Grade 2	2	0.9	—	0
All grades	25	11.1	—	0

^a Excluding six smoking cotton workers and one smoking silk worker.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4. Respiratory symptoms in smoking cotton and silk workers (men only).

Symptom	Cotton workers (N = 144)		Silk workers (N = 101)	
	N	%	N	%
Chronic cough	42	29.2	12	11.9**
Chronic bronchitis	52	36.1	12	11.9**
Chest illness (> 1) past three years	19	13.2	2	2.0*
Byssinosis				
Grades 1/2 + 1	2	1.4	—	0
Grade 2	6	4.2	—	0
All grades	8	5.6	—	0*

* $p < 0.01$, ** $p < 0.001$.

in exposure was essentially limited to two levels (one at approximately 0.5 mg/m³ and the other at approximately 1.4 mg/m³). No information was available on either the work histories of the subjects or on past dust levels in the mills. Therefore only the effects of current exposures could be evaluated.

Population

Eight hundred and eighty-seven workers participated in the study, and completed questionnaires were ob-

Table 5. Respiratory symptoms in nonsmoking cotton and silk workers (men and women).

Symptom	Cotton workers (N = 295)		Silk workers (N = 337)	
	N	%	N	%
Chronic cough	41	13.9	17	5.0**
Chronic bronchitis	40	13.6	18	5.3**
Chest illness (> 1) past three years	14	4.7	5	1.5*
Byssinosis				
Grades 1/2 + 1	21	7.1	—	0
Grade 2	3	1.0	—	0
All grades	24	8.1	—	0

* $p < 0.05$, ** $p < 0.001$.

Table 6. Respiratory symptoms in smoking and nonsmoking cotton textile workers (men only).

Symptom	Smokers (N = 144)		Nonsmokers (N = 69)	
	N	%	N	%
Chronic cough	42	29.8	9	13.6*
Chronic bronchitis	52	36.1	10	15.2**
Chest illness (> 1) past three years	19	13.2	2	2.9*
Byssinosis				
Grades 1/2 + 1	2	1.4	—	0
Grade 2	6	4.2	1	1.4
All grades	8	5.6	1	1.4

* $p < 0.05$, ** $p < 0.01$.

tained on all the subjects. The demographic and health characteristics of the cotton and silk populations are shown in table 2. The workers in both groups were generally young adults, with a mean tenure of employment of approximately 16 years. All but eight (0.9 %) of the women were nonsmokers. Although a greater proportion of the exposed men were smokers, the mean quantity of cigarettes smoked by the smoking men was less than 10 pack-years for both the cotton and silk workers. There were virtually no exsmokers (N = 1), and only four cotton and two silk workers had ever quit smoking for six months or longer.

Symptoms

Byssinosis, chronic nonproductive cough, chronic bronchitis, and acute respiratory illnesses were all more prevalent among the cotton textile workers than among the silk workers (table 2). The prevalence of byssinosis was 7.6 % among the cotton textile workers, and no silk workers reported byssinosis symptoms. Of the 34 workers with byssinosis (all grades), significantly more of them also complained of chronic bronchitis ($p < 0.01$) and chronic cough ($p < 0.001$) than their co-workers without byssinosis. Most cases of byssinosis were mild (grade 1/2 or 1), and byssinosis was reported much more frequently by nonsmoking women than nonsmoking men, 11.1 and 1.4 %, respectively (tables 3 and 6).

Further stratification by smoking habit revealed an excess of respiratory symptoms in both smoking cot-

Figure 1. Prevalence of chronic bronchitis among smoking and nonsmoking cotton and silk workers (men only).

Figure 2. Prevalence of chronic cough among smoking and nonsmoking cotton and silk workers (men only).

ton workers (table 4) and nonsmoking cotton workers (table 5) when compared with silk workers. An internal analysis of respiratory symptoms in cotton workers revealed that smoking cotton workers reported all respiratory symptoms except byssinosis significantly more frequently than nonsmoking cotton workers (table 6).

The combined effect of cotton dust exposure and smoking on the prevalence of chronic bronchitis was found to be greater than the sum of the two independent risks (figure 1). This greater than additive effect was also observed for chronic nonproductive cough (figure 2). The adjusted odds ratios for the effect of working in the cotton mills on the prevalence of chronic bronchitis, chronic cough, and frequent chest illness were estimated from three logistic regression models. (No odds ratio could be computed for byssinosis because none of the silk workers reported symptoms compatible with byssinosis.) Age, smoking, and gender were included in each of the regression models. The three odds ratios were statistically significant ($p < 0.001$) and were estimated to be 3.3 (95 % confidence interval 2.1 to 5.2), 4.7 (95 % confidence interval 2.1 to 10.6), and 2.9 (95 % confidence interval 1.1 to 4.6) for chronic bronchitis, frequent chest illness, and chronic cough, respectively. However, when current dust level was used to measure exposure in an internal analysis restricted to the cotton workers, no association was found between exposure and any of the respiratory symptoms.

Discussion

Byssinosis has been reported in cotton textile workers in most of the developed world. As developing countries expand their textile industries, reports of byssinosis in-

crease. Such reports have come from Egypt (8), Sudan (17), Tanzania (26), and Hong Kong (25). This report describes the first epidemiologic study of cotton textile workers in China using diagnostic criteria and equipment similar to those used in the United States and Great Britain.

Our analysis has shown an excess of respiratory symptoms among cotton textile workers in China when compared with silk workers after controlling for the effects of smoking. The unusually high prevalence of grade 1/2 byssinosis symptoms relative to grade 1 symptoms can be explained by the unique work schedules in these mills. All workers (cotton and silk) work on 8-d rotation: two day shifts, followed by two evening shifts, two night shifts, and then 2 d of rest. Although all the workers were surveyed after the 2-d rest period, there were two additional periods in the week when the workers were away from exposure for 24 h, ie, when they change shift rotations at the end of each 2-d cycle. Hence, the clinical definition and grading of byssinosis needed to be adapted to this particular work pattern (Schilling RSF, personal communication). We classified workers who reported definite work-related symptoms as grade 1/2, regardless of whether they could remember the symptoms as occurring on the first day back from a 2-d rest. There were then 14 workers (3.1 %) with symptoms of byssinosis by the classical grading scheme plus an additional 20 (4.5 %) with mild byssinosis according to the adapted classification. It is likely that a number of the workers with grade 1/2 byssinosis would actually have been classified as grade 1 or more if further refinement in the questionnaire had been possible.

Though the workshift rotation explains the unusual pattern of grades of byssinosis, it does not explain the low overall prevalence of byssinosis and the generally mild nature of the symptoms (only 2.6 % grade 2).

There are three plausible explanations for this finding. First, the relatively young age and short work tenure of this population may be sufficient to explain the predominance of early stage byssinosis (11, 14, 20). Second, the medium to fine grade of the cotton used and low trash/leaf content of the hand-picked cotton may have resulted in cotton dust which was somewhat less "biologically active" (1, 4). Finally, the plant physicians had informed us that workers who develop respiratory diseases such as tuberculosis or "asthma" are systematically removed from areas of cotton dust exposure. It seems likely that some of these "asthmatics" were misdiagnosed cases of byssinosis. This informal medical protection removal policy may therefore have resulted in an underestimate of the true prevalence of byssinosis in the two mills.

The prevalence of byssinosis was substantially higher among nonsmoking women than nonsmoking men, 11.1 and 1.4 %, respectively. Several other investigators have also found more byssinosis among nonsmoking female workers (2, 27). It is unlikely that the observed gender difference is attributable to true physiological differences between men and women. The difference in byssinosis prevalence rates is more likely to reflect either a difference in symptom reporting by sex or a systematic misclassification of exposure by sex. Among the nonsmoking cotton workers in this study population, however, the prevalences of non-specific respiratory symptoms were very similar between the men and women, and nondifferential reporting is suggested. In each of the studies in which a gender difference has been observed, exposure was defined only according to work area. It may be that within a work area, women's job duties result in systematically higher exposures than those of male workers. In order to better understand the relationship between byssinosis and dust exposure, more emphasis is needed in future studies on the accurate assessment of personal exposure.

We were not able to demonstrate a smoking-exposure interaction in the production of byssinosis symptoms, possibly because the number of smokers in the mills was small and the amount of smoking quite low compared with that of western workers (13). Moreover, the range of exposure levels present in these cotton mills was narrower than reported in most other studies (3, 22, 23). Our environmental assessment revealed that there were basically two levels of exposure, a low median dust level in the 0.45–0.6 mg/m³ range and another in the 1.07–1.57 mg/m³ range. In the mills studied by Merchant et al (22) the maximum dust level was almost 20 times the smallest, whereas in these mills the range was only threefold. This limited range of exposure will obviously limit the usefulness of a dose-response model. Other studies of lint-free (eg, vertical elutriated) dust and byssinosis prevalence have found a strong linear relationship between the two, although the slopes of the curves obtained by different investigators vary greatly (3, 22, 23). Moreover there have

also been recent epidemiologic and experimental studies which relate cotton dust "potency" or "toxicity" to airborne bacterial endotoxin levels (5, 13, 30). Endotoxin levels in the bale cotton and elutriated dust samples in these two Shanghai mills revealed high endotoxin levels in Chinese-grown cotton, and over 90 % of cotton processed in these mills was Chinese-grown (28). As with elutriated dust levels, symptoms were not associated with air endotoxin levels in our preliminary analysis. A more refined model will be constructed for the comparison between elutriated dust and air endotoxin levels in this population.

Our results are consistent with prior evidence that chronic bronchitis is associated with work in the cotton textile industry (2, 11, 14, 20, 21, 30). Our data also suggest that there is a greater than additive effect of exposure and cigarette smoking on the prevalence of chronic bronchitis. The prevalence of chronic bronchitis was significantly higher in nonsmoking cotton textile workers compared with nonsmoking silk workers, 13.6 and 5.3 %, respectively, and occurred three times more frequently than byssinosis in the cotton worker population. In addition, the byssinotic workers reported significantly more chronic bronchitis and chronic cough than the nonbyssinotic cotton workers, which corroborates earlier findings of Merchant et al (21), Zuskin & Valic (35), and the more recent findings of Haglund et al (12). This association between chronic bronchitis and byssinosis, together with pathology studies, to date suggest a pattern of asthmatic bronchitis (29). This development has led some investigators to believe that byssinosis is actually a chronic bronchitis process with superimposed acute phenomena (9). The characteristic acute features of chest tightness, shortness of breath, and acute decrement in ventilatory function distinguish byssinosis from chronic bronchitis. In the late stages of byssinosis the characteristic periodicity is lost, and differentiation becomes more difficult. The difficulty in understanding the relationship between byssinosis and chronic bronchitis may be less one of pathophysiology than of definition. Byssinosis as defined by Schilling is based only on acute symptoms (31) except for grade 3, in which there must be evidence of disability. Chronic bronchitis is defined by symptoms persisting for months and years.

China currently leads the world in cotton consumption and is a major producer of cotton (15). China's textile industry continues to expand, employing greater numbers of workers every year. The respiratory problems of Chinese cotton textile workers will assume greater importance in the future, and they currently pose a major challenge in the field of preventive medicine. Furthermore, there are a number of problems related to cotton dust exposure which can be addressed by prospective studies in China: follow-up of nonsmokers exposed to moderate and low levels of lint-free dust; the role of gram negative endotoxin; the male-female distribution of symptoms; and long-term ventilatory function changes. Well-designed longitu-

dinal studies in China will undoubtedly make significant contributions to our collective understanding of respiratory disease in relation to cotton dust. Prospective studies need to be undertaken in China to provide a better definition of chronic respiratory symptoms and pulmonary function among cotton textile workers. This study provides the cohort and establishes a base line for future investigations.

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References

- Batawi MA, Shash EL, El-Din S. An epidemiological study on aetiological factors in byssinosis. *Int Arch Gewerbepath Gerwerbehig* 19 (1962) 393—402.
- Beck GJ, Schachter EN, Maunders LR, Schilling RSF. A prospective study of chronic lung disease in cotton textile workers. *Ann Int Med* 97 (1982) 645—651.
- Berry G, Molyneux MKB, Tomblinson JBL. Relationships between dust level and byssinosis and bronchitis in Lancashire cotton mills. *Br J Ind Med* 31 (1974) 18—27.
- Boehlecke B, Cocke J, Bragg CK, Hancock J, Pestunk E, Piccirillo R, Merchant J. Pulmonary function response to dust from standard and closed boll harvested cotton. *Chest* 79 (1981): 4 suppl, 77—81.
- Castellan RM, Olenchock SA, Hankinson JL, Millner PD, Cocke JR, Bragg CK, Perkins HH, Jacobs RR. Acute bronchoconstriction induced by cotton dust: Dose-related responses to endotoxin and other factors. *Ann Int Med* 101 (1984) 157—163.
- Christiani DC, Eisen EA, Wegman DH, Ye T, Lu P, Gong Z, Dai H. Respiratory disease in cotton textile workers in the People's Republic of China: II Pulmonary function results. *Scand J Work Environ Health* 12 (1986) 46—50.
- Corn J. Workplace exposure zones for classification of exposures. *Am Ind Hyg Assoc J* 40 (1979) 47—54.
- El-Batawi M. Byssinosis in the cotton industry of Egypt. *Br J Ind Med* 19 (1962) 126—130.
- Elwood PC. Byssinosis. *Practitioner* 203 (1969) 779—795.
- Ferris BG. Epidemiology standardization project. *Am Rev Respir Dis* 11: part 2 (1978) 7—59.
- Fox AJ, Tomblinson JBI, Watt A, Wilkie AG. A survey of respiratory disease in cotton operatives: Part II Symptoms, dust estimation, and the effect of smoking habit. *Br J Ind Med* 30 (1973) 48—53.
- Haglund P, Lundholm M, Rylander R. Clinical symptoms in cotton mill workers in Sweden. *Arch Hig Rada Toksikol* 30 (suppl) (1979) 927—931.
- Haglund P, Lundholm M, Rylander R. Prevalence of byssinosis in Swedish cotton mills. *Br J Ind Med* 38 (1981) 80—85.
- Imbus HR, Suh MW. Byssinosis: A study of 10,133 textile workers. *Arch Environ Health* 26 (1973) 183—191.
- International Cotton Advisory Committee. Cotton world statistics. Washington, DC, 1978.
- Jones RN, Diem JE, Glindmeyer H, Dharmarajan H, Hammad YY, Carr J, Weill H. Mill effect and dose-response relationships in byssinosis. *Br J Ind Med* 36 (1979) 305—313.
- Kogah K. A population study in cotton ginning workers in Sudan. *Br J Ind Med* 26 (1969) 308—313.
- Lammers B, Schilling RSF, Walford J. A study of byssinosis, chronic respiratory symptoms and ventilatory capacity in English and Dutch cotton workers with special reference to atmospheric pollution. *Br J Ind Med* 21 (1964) 124—134.
- Lynch AR. Air sampling for cotton dust: Transactions of the National Conference on Cotton Dust and Health. University of North Carolina, Chapel Hill, NC 1970, pp 33—43.
- Martin CF, Higgins JE. Byssinosis and other respiratory ailments: A survey of 6,631 cotton textile employees. *J Occup Med* 18 (1976): 7455—7462.
- Merchant JA, Kilburn KH, O'Fallon WM, Hamilton JD, Lumsden JC. Byssinosis and chronic bronchitis among cotton textile workers. *Ann Int Med* 76 (1972) 423—433.
- Merchant JA, Lumsden JC, Kilburn KH, O'Fallon WM, Uida JR, Germino UH, Hamilton JD. Dose-response studies in cotton textile workers. *J Occup Med* 15 (1973) 222—230.
- Merchant JA, Lumsden JC, Kilburn KH, O'Fallon WM, Uida JR, Germino VH, Hamilton JD. An industrial study of the biological effects of cotton dust and cigarette smoke exposure. *J Occup Med* 15 (1973) 212—221.
- Molyneux MB, Tomblinson JBL. An epidemiological study of respiratory symptoms in Lancashire mills 1963—66. *Br J Ind Med* 27 (1970) 225—234.
- Morgan PGM, Ong SG. First report of byssinosis in Hong Kong. *Br J Ind Med* 38 (1981) 290—292.
- Mustafa KY. Byssinosis in Tanzanian textile workers. *Lung* 159 (1969) 39—44.
- Noweir MH. Some observations on epidemiologic studies in Egyptian gins, cotton pressing plants and cottonseed oil extraction plants. *Chest* 79 (1981): suppl 4, 15—20.
- Olenchock SA, Christiani DC, Mull JC, Ye TT, Gong ZC, Lu PL. Endotoxins in baled cottons and airborne dusts in textile mills in the People's Republic of China. *Appl Environ Microbiol* 46 (1983) 817—820.
- Rokke GB. The pathology of byssinosis. *Chest* 79 (1981): suppl 4, 67—70.
- Rylander R, Imbus HR, Suh MW. Bacterial contamination of cotton as indicator of respiratory effects among cardroom workers. *Br J Ind Med* (1979) 36: 299—304.
- Schilling RSF, Hughes JPW, Dingwell-Fordyce J, Gipson JC. An epidemiologic study of byssinosis among Lancashire cotton workers. *Br J Ind Med* 12 (1955) 217—227.
- US Department of Health, Education, and Welfare. Criteria for a recommended standard: Occupational exposure to cotton dust. US Government Printing Office, Washington, DC 1975. (DHEW publication no (NIOSH) 75—118).
- Xue HL. Initial observations on byssinosis [in Chinese]. *Chin Med J* 50 (1964) 389.
- Xue HL. Some problems in the study of byssinosis [in Chinese]. *Occup Health Environ Med* 3 (1981) 188—191 and 4 (1981) 247—248.
- Zuskin E, Valic F. Respiratory symptoms and ventilatory function changes in relation to length of exposure to cotton dust. *Thorax* 27 (1972) 454—458.

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