Women's respiratory health in the cotton textile industry: an analysis of respiratory symptoms in 973 non-smoking female workers

William S Beckett, C Arden Pope, Xi Ping Xu, David C Christiani

Abstract

As part of a 1992 survey of both environmental and occupational determinants of health, 973 non-smoking women aged 20-40 years who were employed in three comparable modern Chinese cotton textile mills were given a questionnaire that included questions on standard respiratory history and symptoms. All women had some potential exposure to cotton dust; mean employment was 8.7 years. Comparisons were made between those with lowest or no current exposure (job classification in administration, quality control, and testing, $n = 112$) and those in the more heavily exposed classifications (yarn production areas, $n = 861$). Association of symptoms with job was tested by logistic regression, adjusting for age, passive smoking at home, and the use of home coal burning stoves. Odds ratios for prevalence of current frequent symptoms in those working in production jobs, after adjustment for home exposure to passive tobacco smoke and coal heating, were frequent cough 2.23 (95% confidence interval (95% CI) 1.05-4.75), frequent phlegm 3.24 (1.54-6.84), shortness of breath 4.54 (1.40-14.72), and wheeze 2.96 (1.16-7.55). Nine cases with grade I byssinosis (chest tightness or shortness of breath on return to work after two days off) were found; all were in production jobs. In these non-smoking women textile workers, chronic respiratory symptoms were associated with job category after correction for domestic indoor air quality. These data support evidence for an increased prevalence of respiratory disease in populations exposed to cotton dust.

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The occurrence of frequent respiratory symptoms in industrial workers may be one of the early or late findings of reversible or chronic lung disease. In a sample of the general population, the presence of respiratory symptoms has recently been correlated with risk for accelerated decline in lung function.¹ High rates of non-specific respiratory symptoms in relation to occupational dusts and other substances is not rare, and they have been detected in large surveys of samples of the

general adult population in the United States and China.^{2,3}

The respiratory health of women in relation to exposure at work has been studied less often than that of men. Sex specific differences in outcomes of respiratory health such as symptoms, loss of lung function, and incidence of lung cancer have been found in relation to active cigarette smoking.⁴ It has, however, been difficult to separate the effects of methodological differences in the selection of a control population and sex differences in smoking pattern from true biological variation in susceptibility to cigarette smoke. Sex specific differences in health in response to environmental exposure and occupational agents have been described. For example, appreciably different rates of byssinosis have been described between non-smoking male and non-smoking female cotton textile workers in Shanghai, People's Republic of China. There was an 11.1% prevalence of byssinosis in 226 non-smoking female cotton textile workers and a 1.4% prevalence in 69 non-smoking male cotton textile workers.⁵ As sex specific patterns of employment continue to change in many developed and developing countries, more focus on sex related differential dose-response relations may be appropriate, not only with regard to reproductive health, but also for respiratory and other outcomes.

Our study of respiratory symptoms focuses on a large and socially homogeneous cohort of non-smoking women textile workers. Cigarette smoking has been an important variable in many previous studies of the respiratory effects of cotton dust.⁶ In this large group of non-smokers, the opportunity to find the important determinants of respiratory symptoms was made possible by simultaneous inquiry into occupational, outdoor environmental, and home environmental determinants of symptoms. We have examined in more detail the relations of symptoms to environmental factors outside the work place (unpublished data) and this may provide useful comparisons of the importance of different environmental factors on respiratory health in this population. The large number of non-smokers of the same sex and the homogeneity of the study population (in marital state, age, geographical area, occupation) provided an opportunity to measure the magnitude of the effects of current occupational exposure to dust in these cotton textile mills on common respiratory symptoms.

Occupational Medicine Program, Departments of Internal Medicine and Epidemiology and Public Health, Yale University School of Medicine, and John B Pierce Laboratory, New Haven, Connecticut USA
W S Beckett

Environmental Epidemiology Program and Occupational Health Program, Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts USA
C A Pope
X P Xu
D C Christiani

Requests for reprints to:
Dr William S Beckett,
Occupational Medicine
Program, Yale University
School of Medicine, 333
Cedar St, New Haven, CT
06510, USA.

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Subjects and methods

SUBJECTS

The 973 women in this study were part of a larger group of 1035 women all of whom were employed in three modern cotton textile mills in Anhui Province, China, and who participated in a cross sectional study of environmental and occupational determinants of health in 1992. After selection of the initial study population of women based on employment in one of three cotton textile mills, further selection was performed to include in the final 973 subjects only women who were between 20 and 40 years of age, married, non-smokers, and who had completed a middle school education or higher.

HEALTH STUDY

Information was gathered by trained nurse interviewers who gave a detailed questionnaire face to face in the workplace. Respiratory symptom questions were taken from a Chinese language questionnaire based on the American Thoracic Society DLD 1978 respiratory questionnaire.⁷ This was translated from English to Chinese, then from Chinese back to English by a different translator to check the accuracy of translation. It was then re-evaluated for clarity, and the Chinese version corrected. Written in standard Mandarin Chinese, it was given in the verbal dialect of the region by local interviewers.

All subjects were working actively at the time of the study in one of three cotton textile mills in Anhui Province. Two of these mills, Huaibei first textile mill (mill 1) and Huaibei second textile mill (mill 2) were built in 1978; the third, Suzhou textile mill (mill 3), was built in 1984. Starting with the raw material (primarily hand picked, ginned, cotton bales), each mill used electrically powered equipment for the preparation of the yarn (opening, cleaning, carding, spinning) and weaving of cotton cloth. The three mills produced similar products and had comparable facilities, equipment, and manufacturing processes. Each mill ran three full eight hour shifts. Workers were on rotating workshifts, with an eight day cycle and a forward rotation sequence, so that they worked two eight hour day shifts, two eight hour evening shifts, and two eight hour night shifts followed by 48 hours off. Most of the subjects had this shift pattern, but some of the administrative workers did not rotate shifts.

Variables in occupational exposure included years of employment in the textile industry, job classification, and self reported years of occupational exposure in areas described by the workers themselves as low, medium, and high dust areas. Passive smoke in the workplace was not assessed because smoking was not allowed on the production floors in these facilities, although it was permitted in some administrative office areas. The effect of home indoor air quality on respiratory symptoms was assessed by questions on the numbers of people in the married

woman's household, the size of the home, the number of cigarette smokers in the home, and the use of specific types of indoor sources of combustion, which in this region are usually unvented soft coal burning stoves. Socioeconomic information on all subjects included monthly salary plus bonuses, husband's monthly salary plus bonuses, size of home (expressed in m² of floor space), and the highest educational level attained by the woman.

Respiratory history and respiratory outcomes were assessed in detail both for current symptoms and diagnosed respiratory illnesses. Specific respiratory outcomes evaluated were chest illness with increased cough or phlegm in the past three years, usual cough, usual phlegm, shortness of breath with exercise, and a history of wheezing. A positive response to each of the following questions was used in the final analyses of data: Chest; "Have you had an episode of chest illness with increased cough or phlegm during the past three years?" Cough; "Do you usually cough the first thing in the morning or during the day or night?" Phlegm; "Do you usually bring up phlegm from your chest first thing in the morning or any phlegm from your chest during the day or night?" Shortness of breath; "Do you get short of breath when you walk with other people your own age at an ordinary pace on level ground?" Wheeze; "Do you ever have wheezing or whistling from your chest?"

Also, the time of symptoms related to the work shift was ascertained separately to examine for specifically work related symptoms. The presence of chest tightness or shortness of breath occurring on return to work after two days off, the classical definition of grade I byssinosis, was also determined.

STATISTICAL ANALYSES

The primary hypotheses of the study were that current and past occupational exposure to cotton dust at work contributes to the prevalence of chronic respiratory symptoms and the incidence of acute chest illnesses, as well as to acute symptoms related to work. To test these hypotheses, comparisons of women in different categories of exposure were made, adjusting for factors previously shown to affect the rate of reporting respiratory symptoms, including age, exposure at home to passive cigarette smoke, and exposure at home to unvented coal burning stoves, which have been found to contribute to respiratory symptoms in Anhui Province.

The association of these outcomes with occupational exposure was analysed by stratifying the data across the exposure categories. Prevalence rates for each of the symptoms were calculated across strata. Multiple logistic regression was used to evaluate the association between occupational exposure and symptoms while correcting for age, exposure to passive smoke, mill, and home combustion sources.^{8,9}

Results

Table 1 shows the characteristics of subjects according to the two separate exposure classification indices. In the first, which uses two categories of job (administration or quality control as a lower exposure category *v* production as a higher exposure category) the characteristics of subjects in these two broad exposure categories are compared. In the second, which uses workers' reported exposure to dust (self reported dust exposure: low, mixed, mid, high) the estimated category of exposure during the subjects' years of employment in the textile mill is used to categorise chronic exposure. (Those who reported working in more than one category during their employment were included in the mixed dust level exposure group.)

The mean age of all subjects was 28 years, and the mean years of employment in the textile industry was 8.7 years. Forty nine per cent worked in mill 2, 36% in mill 3, and 15% in mill 1. There were 112 women (12%) in the administration, quality control, and inspection exposure category, and 861 (88%) in production. All of the subjects reporting high dust exposure were in the production employment category. Comparisons of groups across exposure categories showed similarity (table 1). Mean ages (29.1 *v* 27.9 years), years of employment (9.4 *v* 8.7 years), size of home (42 *v* 41.2 square meters) and monthly income (113 *v* 112 Chinese yuan) were comparable between these two groups, as were the percentage with cigarette smokers living in the home (71.4 *v* 70.8%), and the percentage with coal burning stoves in the home (27.7% *v* 35.9%).

Table 2 shows crude prevalence rates for the five chronic respiratory symptoms by exposure groups and the two exposure classification indices, job and self reported exposure. Odds ratios for chronic respiratory symptoms (the likelihood of having the symptom in the more heavily exposed production workers divided by the likelihood of having the symptom among the administrative and quality control workers) are shown first without adjustment (table 3, production) and then after adjustment for age, socioeconomic

state, smokers in the home, and use of coal burning stove (table 3, adjusted); 95% confidence intervals (95% CIs) are presented for these outcomes after adjustment. Cough, phlegm, shortness of breath, and wheeze were significantly correlated with exposure in the workplace after adjustment for other factors, with odds ratios after adjustment ranging from 2.23 (cough) to 4.54 (shortness of breath). Reported chest illness with increased phlegm during the past three years was not significantly associated with exposure in the workplace.

A classic symptom of byssinosis as described by Roach and Schilling, chest tightness or shortness of breath after two days off work (byssinosis grade I),¹⁰ was reported by 11 women, all of whom were employed in production areas (table 2).

Prevalence of respiratory symptoms was not as strongly associated with self reported occupational exposure to dust (table 3). Odds ratios for symptoms reported among those in the mixed, mid, and high groups of self reported exposure to dust relative to the low exposure group were generally greater than unity but not statistically significant. The prevalence of chest illness, cough, wheeze, and phlegm were not significantly different across mills. For shortness of breath, the prevalence was significantly less in mill 3 (the Suzhou textile mill), the most recently constructed of the three mills.

Discussion

The prevalence of excess chronic respiratory symptoms other than byssinosis in those who are exposed occupationally to cotton dust has often exceeded the prevalence of byssinosis.^{5 11 12} Because of their non-specificity the relations of these symptoms to occupational exposure, cigarette smoking, atmospheric pollution, or other factors has been difficult to quantify.¹³ The finding of respiratory symptoms—cough, phlegm, shortness of breath, and wheeze—significantly correlated with an occupational exposure gradient after adjusting for age, passive exposure to smoke, and home heating supports other data indi-

Table 1 Characteristics of non-smoking women textile workers with reference to demographic data, occupational exposure, home air quality, and socioeconomic variables

	All	Admin /QC*	Production	Dust: low	Dust: mixed	Dust: mid	Dust: high
Number	973	112	861	68	142	503	260
Age (y)	28.0	29.1	27.9	29.3	28.7	28.2	27.1
Employment (y)	8.7	9.4	8.7	8.2	10.1	8.9	7.8
In production (%)	88.5	0.0	100.0	45.6	69.0	93.8	100.0
High exposure (y)	2.6	0.9	2.9	0	3.8	0	7.8
Mid exposure (y)	5.1	4.1	5.3	0	3.7	8.9	0
Low exposure (y)	1.0	4.4	0.5	8.2	2.7	0	0
Mill 1 (%)	15.2	17.9	14.9	20.6	12.7	22.1	1.9
Mill 2 (%)	48.6	42.0	49.5	36.8	45.8	53.1	44.6
Mill 3 (%)	36.2	40.2	35.7	42.6	41.5	24.9	53.5
Home coal heat (%)	34.9	27.7	35.9	25.0	33.8	31.8	44.2
With smokers in home (%)	70.9	71.4	70.8	72.1	65.5	72.0	71.5
Home size (m ²)	41.3	42.0	41.2	43.4	40.1	42.1	39.8
No living in home	3.3	3.2	3.3	3.1	3.3	3.3	3.5
Monthly income†	112	113	112	119	113	117	101
Husband's monthly income†	144	144	144	148	147	147	134

*Administration, quality control, or inspection job category.

†Monthly salary plus reported bonuses (Chinese yuan).

Table 2 Percentage reporting respiratory symptoms among non-smoking women with respect to job classification or self reported exposure to cotton dust

	Job			Self reported exposure			
	All	Admin/ OC*	Product†	Dust: low	Dust: mixed	Dust: mid	Dust: high
Chest‡	7.2	7.1	7.2	7.4	8.5	7.3	6.2
Cough	12.7	7.1	13.5	10.3	12.7	13.7	11.5
Phlegm	18.0	7.1	19.4	13.2	17.6	17.4	19.6
Sob§	9.2	2.7	10.1	4.4	6.3	10.7	9.2
Wheeze	9.9	4.5	10.6	8.8	13.4	10.1	7.7
Byssinosis¶	1.1	0.0	1.3	1.5	3.5	1.0	1.0
Cough after 2 days off work	0.4	0.9	0.3	1.5	0.0	0.2	7.7

*Job classification in administration or quality control indicates low or no cotton dust exposure.

†Job classification in a production area of the textile mills indicates higher chronic cotton dust exposure.

‡Chest illness in the past three years.

§Shortness of breath with exercise.

¶Chest tightness or shortness of breath after two days off work (grade I byssinosis).

Table 3 Estimated odds ratios in non-smoking women textile workers for general respiratory symptoms with respect to job title and years of self reported dust exposure at varying levels

Job title	Chest‡	Cough	Phlegm	SOB‡	Wheeze
Admin/QC	1.00	1.00	1.00	1.00	1.00
Production§	1.01	2.02**	3.13***	4.08**	2.53**
Adjusted¶ (95% CI)	1.11 (0.51–2.41)	2.23** (1.05–4.75)	3.24*** (1.54–6.84)	4.54** (1.40–14.72)	2.96** (1.16–7.55)
Self reported dust exposure:					
Low	1.00	1.00	1.00	1.00	1.00
Dust exposure:					
Mixed	1.16	1.27	1.40	1.47	1.60
Adjusted (95% CI)	1.27 (0.39–3.45)	1.31 (0.58–2.31)	1.41 (0.66–2.93)	1.60 (0.38–15.59)	1.68 (0.61–4.18)
Dust exposure:					
Mid	1.00	1.39	1.43	2.61	1.17
Adjusted (95% CI)	1.10 (0.38–2.64)	1.47 (0.25–11.44)	1.45 (0.68–2.98)	2.89* (0.79–8.58)	1.29 (0.48–2.82)
Dust exposure:					
High	0.83	1.14	1.60	2.20	0.86
(Adjusted 95% CI)	(0.29–2.34)	(0.55–3.11)	(0.77–3.34)	(0.64–7.55)	(0.33–2.23)

*p < 0.10; **p < 0.05; ***p < 0.01.

‡Chest illness in the past three years.

§Shortness of breath.

¶Odds ratio for presence of respiratory symptoms before adjusting for exposure to passive cigarette smoke in the home and for type of home heating.

¶Odds ratio for presence of respiratory symptoms after adjustment for exposure to passive cigarette smoke in the home and for type of home heating.

SOB = Shortness of breath with exercise.

cating a direct effect of exposure to cotton dust on these non-specific respiratory symptoms. Studies focusing on the occupational respiratory health of women have been reported less often than in men. This has been less true in studies of the effects of cotton and other textile fibres, as women often constitute most of the textile manufacturing workers. There is a plausible basis from respiratory, pharmacological, and toxicological studies to suggest sex related variability in susceptibility to some inhaled agents.^{14,15} Attempts to evaluate such differences in human populations may be confounded by differences in male and female prevalence of cigarette smoking, and by differing secular trends between male and female cohorts in the starting and stopping of cigarette smoking.⁴

China is one of the world's main producers and consumers of cotton, and has a very large cotton textile industry. Measures to control dust have reduced the rates of byssinosis and other respiratory symptoms, yet byssinosis remains an important occupational disease in many developing countries.¹⁶ A recent study by Christiani *et al* of Chinese cotton textile workers employed in two cotton textile plants in Shanghai reported a higher prevalence of

byssinotic symptoms among women than men.⁵ Our study, which focuses on a large group of non-smoking women textile workers in a different region of China, also shows chronic work related respiratory symptoms. The selection of control populations differs between these studies. In the Shanghai study controls were from silk textile plants, whereas in our study a gradient of exposure was assigned between jobs within the three cotton textile mills. The odds ratios for non-specific chronic respiratory symptoms among production workers were similar.

Although direct comparisons of cotton dust or endotoxin are not available, crude rates of symptoms in this study were lower than were found in many older studies of cotton textile workers including the female non-smoking cotton textile workers reported by Christiani *et al* in 1986,⁵ suggesting that modern mill engineering and dust control measures may have made the occupational exposures lower. When current respiratory symptoms were compared independently with a measurement of cotton dust and simultaneous measurement of endotoxin concentrations in the Shanghai cotton mills, endotoxin concentrations (but not elutriated dust concentrations) were significantly associ-

ated with chronic bronchitis.¹¹ This may explain our finding of an association of symptoms with employment in production jobs but not with self reported exposure to dust.

All of the subjects in this study who reported grade I byssinosis were employed in the production areas of the cotton mill (table 2). The symptom of increased cough with return to work after two days off may also occur in byssinosis, but is not a defining symptom. The low frequency of reported byssinosis symptoms may have been affected by the rotating shift schedules of production workers in these mills complicating the reporting of these symptoms. The time off during the weekly break (48 hours) is less than the usual weekend break (about 60 hours) of British cotton textile workers in whom these symptoms were originally described, and might reduce the severity of symptoms reported on returning to work.

Previous investigations of respiratory health in cotton textile workers have included analysis of the role of active smoking, but have not evaluated the role of other potential determinants of respiratory symptoms. To our knowledge, no previous studies have examined the contributions of air quality in both the work environment and home environment to respiratory illness in the same group. Our study concurrently assessed domestic passive cigarette smoking and the use of coal burning heating and cooking stoves in the same population. The ability to assess these multiple determinants of symptoms may have been possible in part because the women were all non-smokers, because of their homogeneity in age and socioeconomic state, and because of the large sample size. Each of these environmental factors—occupational exposure, home passive smoke, and home coal heating—contributed significantly to the chronic respiratory symptoms found.

Exposure to cotton, even in modern mills, leads to an increase in prevalence of respiratory symptoms, in non-smokers as well as smokers. These symptoms may be associated

with increased risk of chronic obstructive pulmonary disease. Hence, efforts to control dust exposures in the modern cotton textile industry remain important.

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