International Journal of Occupational Medicine and Environmental Health 2007;20(1):17–24
DOI 10.2478/v10001-007-0011-7

WORK-RELATED RESPIRATORY SYMPTOMS AMONG COTTON-FABRIC SEWING WORKERS

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Abstract
Objectives: An inspection of the sewing unit in a 700-bed hospital revealed that workers employed in this unit complained of cough, shortness of breath, and tightness in the chest. The aim of this cross-sectional study was to assess the prevalence of respiratory symptoms in the sewing workers and dust concentration in the workplace. The obtained results were compared with the control group. **Materials and Methods:** The sewing workers (n = 22, including 19 current and 3 former employees) and 22 housekeepers as controls were included in the study. All the participants responded to the respiratory questionnaire and underwent spirometric measurements, skin prick test, chest X-ray, and methacholine inhalation test. Environmental dust was measured using both an air pump and a vertical elutriator. **Results:** The sewing workers reported more symptoms of phlegm, chest tightness and eye irritation than persons of the control group. Neither clinical investigations nor respiratory disorders under study provided evidence for a significant difference between the sewing workers and the control group. Of the 22 subjects, 2 (9.1%) showed occupational asthma and 4 (18.2%) mucous membrane irritation and organic dust toxic symptoms. The total and respiratory dust was within normal limits, but the dust concentration measured by the elutriator was above the limit value of 0.34 ± 0.09 mg/m^3. After ventilation improvements, the dust level decreased to 0.19 ± 0.06 mg/m^3. **Conclusions:** This study indicated that respiratory and ocular disorders were related to organic dust produced during the sewing process of cotton fabric.

Key words:
Occupational asthma, Respiratory disorders, Organic dust, Cotton fabric, Sewing workers

INTRODUCTION

The Songklanagarind hospital is a 700-bed hospital in the Songklha province, Thailand. During an inspection carried on by the administrative personnel in the sewing unit, the employees complained of cough, shortness of breath and chest tightness. A review of the working processes showed that for most of the working time, all the employees were located in a confined room of 6 • 19 m with a single door at the front and no windows. It was equipped with eight electric ceiling fans, which could induce secondary dust dispersed from the floor. The room contained 17 sewing machines and one large table for cutting cotton fabric with an electric cutting machine. All fabric used in the sewing unit was 100% cotton because synthetic fabric or a mix of cotton and synthetic fabric shrink under autoclaving.

In the cotton fabric production, the raw cotton imported in bales undergoes extensive processing to obtain cotton yarn. The next stage is to prepare the yarn for weaving

This study was supported by the Faculty of Medicine, Prince of Songkla University, Hatyai, Songkhla, Thailand.
Received: December 29, 2006. Accepted: February 23, 2007.
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process, which includes boiling with sodium hydroxide, bleaching with a chlorinated compound or hydrogen peroxide, followed by treatment with sizing agents, such as starch and various polymers used as lubricants to prevent tangling of the yarn. The final stage is the finishing process, which is intended to enhance the properties of the cotton fabric. This process includes the use of several chemicals, such as anticrease agents, flame retardants, water repellents as well as antistatic, antisoiling, antimicrobial, and softening agents [1,2]. Organic dust from cotton fabric in the sewing process is thus a complex mixture of materials derived from processing of cotton fiber and natural contaminants, such as bacteria, endotoxins and molds. Exposure to organic dust is implicated in the etiology of several occupational respiratory diseases, e.g., occupational asthma (OA), byssinosis, allergic alveolitis, chronic bronchitis and the organic dust toxic syndrome [3–5].

The aim of this study was to determine the prevalence of respiratory disorders and dust concentration in the work environment of the sewing workers at the Songklanagarind hospital.

MATERIALS AND METHODS

In the sewing unit, 1 male and 18 female workers are employed. To avoid a healthy worker effect, three employees who had previously resigned from the job were invited to participate in the study. Altogether 22 employees were included. The controls were selected from housekeepers in the inpatient unit who worked within 3 years of case's duration of work, but have never worked in the sewing unit.

The study design was approved by the ethics committee at the Faculty of Medicine, Prince of Songkla University.

Five area air samples were measured using a personal pump (model Gil-Air 5, Gilian instrument Corp., USA) for total dust and a vertical elutriator (developed by the Division of Occupational Health, Ministry of Public Health) for cotton dust. Respiratory dust air samples were obtained from 18 employees using a 10-mm nylon cyclone (Dorr-Oliver) attached to the personal pump. All area and personal samplings were obtained at the workers' breathing zone during their work hours and subsequently analyzed by the gravimetric method.

All employees were interviewed using a modified questionnaire based on the British Medical Research Council respiratory questionnaire and the Thai respiratory questionnaire [6,7]. The collected information included demographic data, complete occupational history, smoking and passive smoking, present illnesses as well as details on any respiratory, ocular, and skin symptoms.

A skin prick test, using an extract of cotton fabric, was prepared according to the method described by Kim [8]. To prepare the extract from cotton fabric dust, the cotton fabric dust was soaked in phosphate-buffered saline (PBS, pH 7.4, 1:10 wt/vol) for 24 h at 4°C. The supernatant was then infiltrated and centrifuged at 3000 rpm for 15 min then the supernatant was vaporized by freeze-dryer. The vaporized dust was distilled in sterile water (1:5 wt/vol) and mixed with an equal amount of sterile glycerine (final volume 1:10 wt/vol). The solution was pricked into the volar surface of the forearm with a sterile, disposable needle (DUOTIP-test, Lincoln Diagnostics Inc, USA). The workers were tested with three common local antigens (Dermatophagoides farinae, Dermatophagoides pteronyssinus, American cockroach), along with glycerine (negative control) and histamine (positive control). A positive reaction was defined as an induration of at least 3 mm larger in diameter than the negative control. Atopy was defined if the subject had positive reaction to two or more allergen extracts. ELISA for specific IgE of cotton-fabric protein was developed using the Lowry method extraction, SDS-PAGE and immunobloting [9]. The protein extract was analyzed by SDS-PAGE and resolved into a band at 60 kD. However, the binding to specific IgE antibodies on the blotted membrane was found in both the positive and negative controls. We also tried another technique of dot blot assay with chemiluminescents, but the method used was unsuccessful.

Spirometric measurements were performed by a trained nurse at the Pulmonary Unit, Internal Medicine Department, Songklanagarind hospital using a standby spirometer (6200 Autobox DL, Sensor Medics Corporation, USA). Spirograms were obtained before work and 4–6 h later. Each worker performed up to eight trials to produce three acceptable curves and the best forced vital capacity

(FVC) and forced expiratory volume at 1 s (FEV_1) recordings were used.

Airway responsiveness was determined using the methacholine challenge test (MCT) according to the American Thoracic Society (ATS) protocol [10]. MCT was also performed at the Pulmonary unit. Solutions were inhaled through a nebulizer connected with dosimeter (SM-1, Pulmonary Data Service Instrumentation Inc., USA). The subjects first inhaled a solution of 0.9% normal saline for 2 min while in a sitting position. They then inhaled the methacholine solution, beginning at 0.06 mg/ml and gradually increased to 0.25, 1, 4 and 16 mg/ml. Spirometric measurements were taken 1–2 min after each inhalation. The categorization of bronchial responsiveness suggested by the ATS was used to interpret the results.

The diagnostic criteria under study were as follows: chronic bronchitis — cough producing sputum for 3 months of ≥ 2 consecutive years; OA diagnosed by the pulmologist and the onset of asthma after entering the sewing unit and either work-related changes in FEV_1 or positive bronchial hyperresponsiveness; byssinosis — chest tightness worse on the first working day in accordance with Schilling's classification; organic dust toxic (ODT) symptoms identified by workers reporting recurrent episodes of fever, symptoms beginning within 4–12 h after work and at least 4 of the following symptoms: cough, chest discomfort, headache, malaise or weakness, shivering, muscle pains, poor appetite and weight loss; mucous membrane irritation (MMI) — nasal and eye irritation, which alleviated on days off.

RESULTS

Nineteen workers of the sewing unit and 3 former employees who had given up the job and 22 controls participated in the study (response rate 100%). Among 3 sewing workers who had left the job, one was diagnosed occupational asthma and advised to leave the job, one had severe ocular and dermal irritation and the other one showed pulmonary tuberculosis. Complete interviews, physical examinations, skin prick tests and chest X-rays were obtained from all 44 workers, but 3 sewing workers could not complete the methacholine inhalation test.

Area samples collected from the sewing room revealed that total dust concentration was not beyond the accepted limit with a mean and standard deviation (SD) of 0.68 and 0.04 mg/m^3. The personal respiratory samples from 18 employees were 0.52 ± 0.06 mg/m^3, which was also within the accepted limit. On a high power microscopic examination, the cotton fabric dust showed the fiber shape as shown in Figure 1. The vertical elutriator was then applied and revealed that the dust level exceeded the limit value of 0.34 ± 0.09 mg/m^3. After the inspection, the hospital committee improved the general ventilation by reconstructing the sewing room so that the air could freely circulate through the room. The dust concentration measured then by the elutriator decreased to 0.19 ± 0.04 mg/m^3 (Table 1).

Most of the employees were middle-aged (median age, 41 years) with an average duration of employment of 12.5 years. The distribution of age, gender, duration of work,

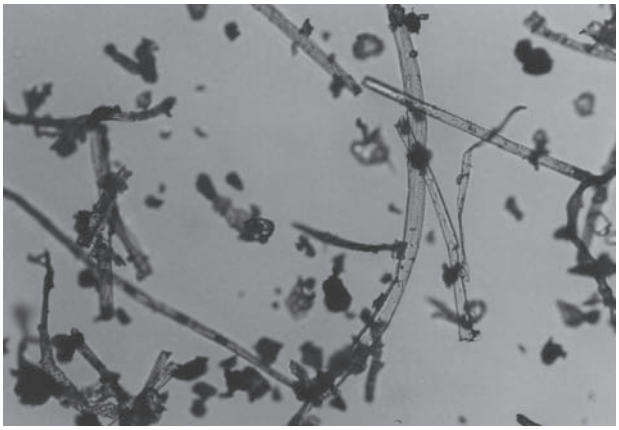

Fig. 1. Cotton fabric dust under high power microscope.

Table 1. Total dust and respiratory dust exposure in the sewing room

	Sample	mg/m^3
Total dust concentration (area sampling)	5	0.68 ± 0.04
Respiratory dust concentration (personal sampling)	18	0.52 ± 0.06
Dust concentration by an elutriator (area sampling)		
Before workplace ventilation improvement	5	0.34 ± 0.09
After workplace ventilation improvement	5	0.19 ± 0.04

TLV-TWA of total dust 10 mg/m^3; TLV-TWA for respiratory dust 3 mg/m^3; TLV-TWA of total dust by elutriator 0.2 mg/m^3; TLV — threshold limit value; TWA — time weighted average.

passive smoking, history of familial allergy showed no difference between the sewing employees and the control group (Table 2). Comparison with the control group showed a higher prevalence of phlegm, chest tightness and ocular irritation in sewing workers than in controls (Table 3). Regarding organic dust toxic symptoms, sewing workers had fever and cough more often than controls (Table 4). Further investigations, including the skin prick test, non-specific bronchial challenge test, chest radiology and spirometry, showed no statistical difference between the two groups. Of the 22 sewing workers, 2 met the case definition of OA and 4 met the criteria of MMI and ODT syndromes (Table 5).

Of the 2 asthmatic patients, one was still working in the sewing unit at the time of the study while the other had left the job due to asthmatic symptoms. The first OA subject was a 46-year-old woman who began sporadically producing phlegm, having a runny nose and sore throat off and on and was diagnosed as having allergic rhinitis 9 years after commencing work at the sewing unit. One year later, she started chest tightness and wheezing at work and bedtime and got better on her days off. Examination on her first visit revealed generalized wheezing in both lungs on forced expiration bilaterally. She had no previous history of asthma or known allergy. The pulmologist diagnosed asthma and treated her with Budesonide (metered dose

Table 2. Characteristics of the sewing and control workers

	Sewing workers (%)	Control workers (%)
Sex		
Male	3 (13.6)	0 (0)
Female	19 (86.4)	22 (100)
Age		
≤ 30	3 (13.6)	–
31–40	6 (27.3)	10 (45.5)
41–50	10 (45.5)	11 (50.0)
51+	3 (13.6)	1 (4.5)
Duration of employment		
≤ 1	3 (13.6)	1 (4.5)
2–4	2 (9.1)	1 (4.5)
5–7	2 (9.1)	1 (4.5)
8–10	3 (13.6)	4 (18.2)
11+	12 (54.6)	12 (68.2)
Passive smoking		
No	20 (90.9)	17 (77.3)
Yes	2 (9.1)	5 (22.7)
History of familial allergy		
No	10 (45.5)	11 (50.0)
Yes	12 (54.5)	11 (50.0)

Fisher's exact test and the Chi square test.

Table 3. Respiratory, eye and skin symptoms in the sewing and control workers

	Sewing workers		Control workers	
	Yes	No	Yes	No
Cough	7 (22.7)	15 (68.2)	5 (22.7)	17 (77.3)
If yes, getting better on days off	4/7	3/7	4/5	1/5
Phlegm*	13 (59.1)	9 (40.9)	4 (18.2)	18 (81.8)
If yes, getting better on days off	7/13	6/13	3/4	1/4
Chest tightness*	14 (64.6)	6 (36.4)	6 (27.3)	16 (72.7)
If yes, getting better on days off	12/14	2/14	4/6	2/6
Wheezing	9 (40.9)	13 (59.1)	4 (18.2)	18 (81.8)
If yes, getting better on days off	8/9	1/9	4/4	0/4
Itchy and runny nose	17 (77.2)	5 (22.8)	11 (50)	11 (50)
If yes, getting better on days off	12/17	5/17	9/11	2/11
Itchy, red and watery eye*	14 (63.6)	8 (36.4)	5 (22.7)	17 (77.3)
If yes, getting better on days off	5/14	9/14	3/5	2/5
Dermatitis	9 (40.9)	13 (59.1)	8 (36.4)	14 (63.6)
If yes, getting better on days off	2/9	7/9	2/8	6/8

* p value < 0.05 by Fisher's exact test.

Table 4. Symptoms related to the organic dust toxic syndrome in the sewing and control workers

	Sewing workers		Control workers	
	Yes	No	Yes	No
Fever*	11 (50.0)	11 (50)	4 (18.2)	18 (81.8)
Cough*	8 (36.4)	14 (63.6)	0 (0)	22 (100)
Chest discomfort	7 (31.8)	15 (68.2)	3 (13.6)	19 (86.4)
Headache	14 (63.6)	8 (36.4)	13 (59.1)	9 (40.4)
Weakness	11 (50.0)	11 (50.0)	4 (18.2)	18 (81.8)
Shivering	2 (9.1)	20 (90.9)	0 (0)	22 (100)
Muscle pain or malaise	14 (63.2)	8 (36.4)	10 (45.5)	12 (54.5)
Decreased appetite	4 (18.2)	18 (81.8)	3 (13.6)	19 (86.4)
Weight loss	1 (4.5)	21 (95.5)	1 (4.5)	21 (95.5)
Symptoms, onset within 4–12 h after work	10 (55.6)	8 (44.4)	4 (25.5)	13 (76.5)

* p value < 0.05 by Fisher's exact test.

Table 5. Clinical examinations and respiratory disorders in the sewing and control workers

	Sewing workers		Control workers	
	Positive	Negative	Positive	Negative
Clinical examinations				
Chest X-ray[a]	2 (9.1)	20 (90.9)	2 (9.1)	20 (90.9)
Skin prick test to cloth dust	2 (9.1)	20 (90.9)	0 (0)	22 (100)
Methacholine challenge test[b]	3 (13.6)	16 (86.4)	1 (4.5)	21 (95.5)
Lung function test[c]				
FVC (% prediction) before work	106 ± 13		96 ± 15	
4–6 h later	106 ± 14		95 ± 14	
FEV_1 (% prediction) before work	98 ± 15		94 ± 13	
4–6 h later	101 ± 12		93 ± 12	
FEV_1/FVC ratio (%) before work	79 ± 7		84 ± 6	
4–6 h later	81 ± 5		84 ± 6	
Respiratory disorder				
Chronic bronchitis	0 (0)	22 (100)	1 (4.5)	21 (95.5)
Occupational asthma	2 (9.1)	20 (90.9)	0 (0)	22 (100)
Organic dust toxic syndrome	4 (18.2)	18 (81.8)	0 (0)	22 (100)
Mucous membrane irritation	4 (18.2)	18 (81.8)	1 (4.5)	21 (95.5)

[a] Small nodule at lung parenchyma 3 and old tuberculosis 1.
[b] Two sewing workers could not complete the methacholine inhalation test due to poor effort and 1 former sewing worker with pulmonary tuberculosis had a moderately severe lung function test, which was contraindicated for the test.
[c] Three former sewing workers not included.
FVC — forced vital capacity; FEV_1 — forced expiratory volume in 1 s.

inhaler) b.i.d. and Salbutamol sulfate (inhaler) p.r.n. She continued to have frequent attacks and regularly maintained asthmatic controller and reliever for two consecutive years. Further investigations performed during this study showed normal chest radiography and the methacholine challenge test caused a 20% fall in FEV_1 (PC20) of 0.25 mg/ml. The allergy skin prick test showed negative reactions regarding 3 common local antigens (Dermatophagoides farinae, Dermatophagoides pteronyssinus, American cockroach) and cotton fabric dust extract. One year after general ventilation improvements have been made to the work area, her asthmatic attacks lessened and she decreased the asthmatic medication from daily to 1–2 times a year.

The other patient was a 37-year-old woman who developed chest tightness and wheezing three years after commencing employment and was diagnosed as OA. Her symptoms occurred 2–3 times a month, but abated on her days off. Six years later, the patient's symptoms gradually increased so her physician recommended to change the job. One year after she had given up the job, she was invited to participate in the study and underwent relevant examinations. She reported an improvement to her respiratory symptoms and stopped taking medication. Her chest radiography was unremarkable. Allergy skin prick tests showed negative reactions to all antigens. The methacholine challenge test one year after cessation of work revealed PC20 of 0.25 mg/ml.

DISCUSSION

Under this study 22 sewing workers were clinically examined, 2 of them were diagnosed OA. These two OA cases had been diagnosed by the pulmologist and the patients started asthma medication before the study period and one was recommended to leave her job, but the other patient still worked at sewing unit. Both patients had asthmatic attacks after commencing sewing work, getting worse at work and getting better on their days off. None of them reported atopic history. The worker who had resigned improved, had no asthmatic attacks and ceased the medication after leaving the job. The one who still worked in the sewing unit changed from regular to intermittent medication after the workplace ventilation improvement had been instigated. On the examination under this study, both patients showed positive results of the methacholine challenge test, though none showed positive skin allergic test. Nevertheless the patient who left the job had the skin prick test performed nine months after leaving the job. The diagnosis for asthma in this survey may be partly consistent with the OA case definition described in the guidelines of the American College of Chest Physicians (ACCP) [11], which include asthma diagnosis, onset of asthma after entering the workplace, association between symptoms of asthma and work and the onset of asthma with a clear association with a symptomatic exposure to an agent in the workplace. Although the association between asthmatic symptoms and work, including their onset evidently linked with exposure, was verified using the clinical

course and long-term follow up, neither serial bronchial hyperresponsiveness nor specific reaction to the challenge test for cotton fabric extract was observed, but the scenario based on clinical histories and physical examination was compatible with OA.

In this study, organic dust toxic syndrome was identified, taking fever and symptoms beginning within 4–12 h as the major criteria and also 4 of the 8 minor symptoms, and yielded the prevalence of 4/22 or 18.2%. The prevalence of ODT reported across various studies widely ranged from 2.5% (mushroom workers) to 36% (agricultural workers), which is partly due to the ODT criteria used in those studies and the occupation selected [12]. Conversely, a previous study among cotton workers [13], using a questionnaire with at least 2 of 5 criteria for ODT (fever, shivering, malaise, weakness and joint or muscle pains) has reported a low prevalence of 1% among cotton spinners and the absence of ODT among cotton weavers [13]. No study carried out among sewing workers is available. A compatible criterion for ODT in this study was more specific and may thus be of interest, though it has been reported outside that conventionally recognized in grain, poultry, cattle, swine, garbage and compost handling industries. The limitation of the symptoms described using a subjective questionnaire alone may not be sensitive enough to distinguish the overlap between ODT and extrinsic allergic alveolitis.

Ocular and nasal irritations have been considered to be relevant biological endpoints for regulating exposures in both textile [14–15] and non-textile settings [16–17]. The finding for eye and nasal irritation symptoms in the study was 18.2%, which is in line with previous studies among textile workers (20.4%) [13] and 17.5% for eye irritation and 11% for nasal irritation [14], though a different definition of MMI was applied. This study defined MMI as eye and nasal symptoms occurring at any time, but improving when away from work, while the two aforesaid studies defined it as ocular and nasal itch or irritation that was worse at work than on rest days. Moreover, these symptoms seemed to bear no relation to the study definition of atopy as judged by the skin prick test to 2 or more common allergen extracts. The findings of no relation between ocular and nasal irritation and atopy were similar to the conclusions drawn from other studies [18–19]. This may imply that the mechanism of these symptoms was more likely due to a direct irritant effect.

Though 3 sewing workers under study reported Monday chest tightness, which is the classical symptom of byssinosis, its frequency — once a year and every alternative year — was not significant and all the controls and the 2 OA patients denied Monday symptoms. Consequently, no subject met the criteria for byssinosis. Several previous studies on byssinosis focused mainly on the effect of raw cotton dust among spinners and weavers, including its immunopathogenesis, but neither the precise etiology nor the pathogenic mechanism of cotton dust-induced respiratory disease has yet been concluded [20–21]. Increasing evidence, however, indicates that cotton dust and its bract are not the only causative agent of byssinosis, but endotoxin contaminants may be the most likely cause or works synergistically with cotton components to enhance airway inflammation [22–24]. Moreover, few studies have demonstrated that cotton washing results in reduced endotoxin and lower bronchoconstriction [25–26]. Since in the fabric processing, cotton yarn is washed, heated and chemically treated, we postulate that organic dust from cotton fabric is a complex mixture containing material from cotton fabric dust, chemical residues from fabric processing and also contaminants from microorganic sources in the work environment (bacterial endotoxin, molds) and might act differently from raw cotton dust.

Our study showed that the concentration of cotton dust measured by an elutriator was higher than the threshold limit value (TLV) of 0.2 mg/m^3, recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) [27], but total and respiratory dusts were not in excess of their TLVs. This is relevant to microscopic features of cotton fabric dust, which showed fiber-shaped dust. This study, however, did not include chemical or endotoxin measurements in the workplace since it was not primarily designed to disentangle separate effects of dust, chemical or endotoxin, but mainly aimed at describing respiratory symptoms in relation to cotton fabric dust exposure.

The result of disease occurrence in this cross sectional study, is not subject to the bias resulting from healthy

worker effect since the data were collected from all the sewing workers, including those who had previously left the job. In the current study, a response rate of 100% of the target population represents a valid sample for the study and the workers were never smokers with long duration of employment. The clinical diagnosis of OA was of significance and according to our current knowledge, there is a paucity of data resulting from studies carried out among sewing workers who are exposed to cotton fabric dust. This study is just one among a few reports on OA occurring among sewing workers.

CONCLUSIONS

This study provided evidence that organic dusts from cotton fabric in sewing process are important in the etiology of respiratory morbidity, such as occupational asthma, mucous membrane irritation and organic dust toxic symptoms. Regarding that organic dust from sewing process is a complex mixture containing material from cotton fabric, chemical residues from the fabric processing and contaminants from microorganic sources in the work environment, the agent or agents responsible for diseases thus remain to be identified. Additional studies are required to verify the effects of endotoxin, molds, and chemical residues in isolation to cotton fabric dust in order to determine the relationship between the independent causative agents and the reported symptoms and diseases. Having obtained such information, valid exposure limits for each agent in the sewing industry could be determined.

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