LUNG FUNCTION DECLINE IN LANCASHIRE TEXTILE WORKERS. A PROVISIONAL ANALYSIS OF A FIVE YEAR LONGITUDINAL STUDY

A. M. Fletcher, R. McL. Niven, C. A. C. Pickering, E. Faragher, C. J. Warburton, H. Francis, L. A. Oldham, D. Fishwick and J. C. G. Simpson
Department of Occupational and Environmental Medicine
The North West Lung Centre, Wythenshawe Hospital
Manchester, England

Abstract

A five year prospective study, documenting respiratory symptoms, measurement of lung function and assessment of airborne dust concentrations, was performed in eight Lancashire textile mills. Two mills processed man-made fibre, two processed a cotton blend, two medium grade cotton and two mills processed waste cotton. Each year, operatives were administered a respiratory questionnaire and invited to perform spirometry, measurements of FEV_1 and FVC were recorded. Work area dust concentrations were assessed by following the Health and Safety Executive EH25 guideline on static dust sampling and dust concentrations within the personal breathing zone were assessed by operatives wearing personal dust samplers over a working shift. In total, 1611 operatives have taken part over the five year study period. For the purpose of this analysis, the data set has been stratified. In total 1394 operatives were included in this analysis, 569 operatives in man-made fibre, 202 operatives processing blend cotton, 413 operatives processing medium grade cotton and 210 operatives processing waste cotton. Both measures of lung function decline were low for all four fibre groups; Man-made fibre FEV_1 decline = -17mls/yr FVC = -11mls/yr, Blend FEV_1 = 4mls/yr FVC = 4mls/yr, Medium FEV_1 = -5mls/yr FVC = -5mls/yr, Waste FEV_1 = -21mls/yr FVC = -20mls/yr. However, man-made fibre and waste processing operatives exhibited greater rates of declines in lung function. Within the man-made fibre group over half of the population have had previous exposure to cotton and this may be reflected in the measures of lung function decline. Within the cotton group lung function decline was greatest in the high dust exposure group, waste cotton workers, suggesting a dose response relationship. Byssinosis was associated with increased cumulative exposure to dust and length of time working in the cotton. Operatives with byssinosis also had lower baseline measures of lung function and greater rates of lung function decline.

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Introduction

Epidemiological studies performed in the cotton industry have reported a relationship between duration of exposure and the development of byssinosis and other respiratory symptoms (Roach, 1960; Fox, 1973; Cinkotai, 1988). Early longitudinal studies have suggested a similar association between duration of exposure and accelerated lung function decline, with an excess in mean annual lung function decline detected in cotton workers compared with controls (Berry, 1973; Zuskin, 1975). However, a recent large scale longitudinal study was unable to reproduce these findings and reported a greater lung function decline in synthetic workers compared with cotton exposed workers, which could not be explained by smoking or duration of employment (Glindmeyer, 1991).

Cotton workers have recently been studied and excess risk of respiratory mortality was not demonstrated (Koskela, 1990; Merchant, 1981). However, a prospective study of a cohort of cotton workers did demonstrate an increased mortality rate in byssinotic compared to non-byssinotics (Hodgson, 1990). A study assessing respiratory disability in ex-cotton workers demonstrated increasing decrements in lung function with increasing dust exposures, however, the authors concluded that the changes were small and similar to the levels of lung function decline seen in light or ex-smokers (Elwood, 1986).

Earlier analysis of those operatives seen in year one and year five of this longitudinal study documented lung function declines in both cotton and man-made fibre workers similar to those found in the general population (Fletcher, 1997). Within man-made fibre workers, multiple regression identified smoking as the predictive factor of increased decline in FEV_{1}. Within cotton workers, increased decline of FEV_1 was predicted by increased levels of personal dust exposure and suggested a dose response relationship.

Under current dust exposures there may still be susceptible individuals at risk of developing chronic respiratory impairment. Although working conditions within the textile industry have improved, controlling levels of airborne dust and use of respiratory protection remain problematic. Furthermore, evidence for the health effects of chronic exposure to cotton dust on respiratory impairment remains controversial.

This five year study is designed to investigate the relationship between current airborne dust exposures, lung function decline, and possible associated predictive factors.

Study Population

Workers from eight textile spinning mills located in the North West of England were recruited into the study.

Two mills processed man-made fibre, two processed a cotton blend, two medium grade cotton and two mills processed waste cotton. For each year of the study, all operatives of each individual mill, were invited to complete a computer administered respiratory questionnaire and perform assessment of lung function.

Questionnaire

The questionnaire used was an adaptation of the Medical Research Council respiratory questionnaire published in 1966 and was administered via a Compaq computer to each operative by one of three investigators.

The questionnaire documented the presence or absence of the respiratory symptoms; cough, phlegm, chest tightness, wheeze and shortness of breath. A work related pattern for these symptoms was defined by an improvement in the symptom on rest days or holidays. Operatives reporting work related chest tightness which was worse on the first working day were classified as byssinotic and graded according to Schilling's classification (Schilling, 1956). In addition demographic details, present occupation and workroom, past work history related to the cotton industry and smoking history were recorded.

Lung Function Assessment

Lung function was measured each year using a Vitalograph dry wedge spirometer, according to the guidelines produced by the ATS Snowbird Workshop (Gardner, 1979). Forced expired volume in one second (FEV_1) and forced vital capacity (FVC) were measured. Operatives were required to perform three blows, with two blows within 5% or 100 mls of each other and the largest measures of FEV_1 and FVC were recorded. All assessments were made with the operative standing and a nose clip was used in cases where spirometry technique was poor. Since the temperature in the workrooms throughout the mills ranged from 16°C to 32°C, spirometry results were read from the ambient temperature pressure saturated with water vapour (ATPS) scale and corrected to body temperature pressure saturated with water vapour (BTPS).

Work Area Dust Sampling

Work area dust sampling was performed according to the regulations laid down in the EH 25 guideline (British Health and Safety Executive, 1975). Rothero and Mitchell L60 samplers loaded with Whatman GFA 37 mm glass microfibre filter papers were used to measure work area dust concentrations. The samplers were enclosed by a pre-filter wire mesh 2 mm pitch gauze cage and positioned on the top of a aluminium ladder at a height of 1.5 metres. The L60 samplers were run for a period of approximately four hours. In addition to the sampler filter papers, control filters were also weighed before and after the sampling exercise. Differences in weight of the filter papers were corrected if any change in weight of the control filters was detected. The volume of air sampled was calculated from the time and flow rate recordings of each sampler. The work area dust concentration was calculated by dividing the weight of dust by the volume sampled and was expressed as mgm^{-3}.

Each mill was able to provide retrospective measurements of cotton dust, throughout the workrooms, dating back to 1981. These measurements were performed following the HSE EH25 guideline. This data, in conjunction with the documented work history obtained from the questionnaire, were used to estimate past cotton dust exposure for each participating operative.

Personal Dust Sampling

Operatives from various occupational groups were asked to wear personal dust sampling equipment during their working shift. Casella AFC sampling pumps (adjusted to run at 2 litres per minute) and Institute of Occupational Medicine (IOM) open face sampling heads (Mark, 1986) with 25 mm microglass fibre filter papers were worn at clavicle level. Changes in weight in the sample filters were corrected for any differences in weight of the control filter papers. Personal dust concentrations were expressed as mgm^{-3}.

A conversion factor was available to convert the measures of cotton dust exposure by work area sampling, dating back to 1981, to comparative levels of personal dust exposures, dependent on workroom and mill (Niven, 1991). Using this conversion factor and the documented work history a cumulative personal dust exposure was calculated for each operative.

Statistical Analysis

The data were analysed using multi-level modelling regression methods. For each individual fibre group, linear regression models were fitted to the FEV_1 and FVC data for each subject separately, from which appropriately weighted averages were obtained for the slopes (rates of change in lung function) and intercept (mean values at start of study period). Similar methods were used for the presence/absence of byssinosis, however, binomial (logistic) models were fitted to produce odds ratios. Cigarette pack years, years worked in the cotton industry and each of the four dust parameters were all found to have positively skewed distributions, therefore, these data sets were converted to natural logarithms for analysis. Results are presented as means or odds ratios and their 95% confidence intervals (CI). All models were fitted using the STATA statistical software using a mixture of random and fixed effects.

Results

Approximately 1000 operatives agreed to take part in the study on a yearly basis. Table one presents the target population, sample population and response rate for each year of the study in the six cotton mills and the two man-made fibre mills. 1611 operatives have been seen on at least one occasion over the five year study period. For the purpose of this analysis the data has been stratified. Physiologically the respiratory airways of humans continue to mature up to the age of 25. Therefore, with this current knowledge, two hundred and eight operatives aged under 25 years were excluded from this analysis. In addition, nine operatives who reported to have moved mill during the study period were also excluded. In total 1394 operatives were included in this analysis, 569 operatives in man-made fibre, 202 operatives processing blend cotton, 413 operatives processing medium grade cotton and 210 operatives processing waste cotton.

Table 2 presents the demographic features of each fibre group. The mean age was similar across each of the fibre groups. There was a greater proportion of females and Caucasians within the two blend mills compared to the remaining fibre groups. The median figure for pack years within each of the cotton fibre groups was much higher than the median figure for man-made fibre.

Total time exposed in the cotton history was calculated for each individual using the current and past work history data. The median figures were much higher in the cotton groups; median time in cotton industry blend group=19yrs (range=0-51yrs), medium group time=17.1yrs (0.1-64yrs), waste group time=12yrs (0.3-52yrs), compared to man-made fibre time in cotton industry=2yrs (range=0-44yrs).

Current personal cotton dust exposure (PD), retrospective personal exposure (PDPAST), current work area cotton dust exposure (SD) and retrospective work area exposure (SDPAST) are presented in table 3. Current personal dust exposures are consistently higher in each of the cotton fibre groups compared to levels of cotton dust exposure assessed by the work area sampling method. All four dust parameters were found to be highest within the waste fibre processing group. Over half of the man-made fibre population reported to have had worked, in the past, within the cotton industry. Therefore, cumulative exposure values were calculated for those individuals. Although the median cumulative exposure values are low in man-made fibre operatives compared to cotton, the range indicates that there are some operatives in man-made fibre who have had high exposures to cotton in the past.

Both measures of lung function decline were low for all four fibre groups (Table 4.). However, the waste cotton and man-made fibre groups exhibited greater declines than the blend and medium fibre groups. Interestingly, the man-made fibre group demonstrated lower baseline levels of lung function than those within the waste fibre group. This findings may be suggestive of a healthy worker effect.

Analysis of lung function decline by sex did not demonstrate any difference within each of the four fibre groups. Analysis by ethnic group demonstrated a statistically significant excess decline of lung function in Caucasians compared to Asians within the waste fibre group and opposite findings in the man-made fibre group; waste cotton group mean FEV_1 decline in Caucasians = -27mls/yr (CI -43,-11), Asians = -2mls/yr (CI -26,22); MMF group mean FEV_1 in Caucasians = -11mls/yr (CI-21,-1), Asians = -25mls/yr (CI-35,-15). No difference between ethnic groups was demonstrated both within and across the blend and medium fibre groups.

Univariate analysis of the effect of doubling years spent in the cotton industry on increasing lung function decline demonstrated similar rates of lung loss found in the man-made fibre and waste cotton groups; mean FEV_1 decline in MMF = -174mls/yr (CI -231,-117), Blend = -103mls/yr (CI-185,-21), Medium = -204 mls/yr (CI-269,-139), Waste = -172mls/yr (CI-227,-117). In comparison the doubling effect of pack years of smoking on lung function decline was low and variable across the fibre groups; mean FEV_1 decline in MMF = -14mls/yr (CI-38,10), Blend = -41mls/yr (CI-84,2), Medium = 15mls/yr (CI-18,48), Waste = -20mls/yr (CI-69,29).

Operatives who reported symptoms of byssinosis at any point over the five year study period were labelled as byssinotic. The study period prevalence of byssinosis was highest in the waste 9% (19 operatives) and medium 5.1% (21 operatives) fibre groups compared to the blend 0.5% (1 operative) and man-made 0.7% (4 operatives) fibre groups. Other epidemiological studies have documented operatives with byssinosis in man-made fibre, however, many of these studies have failed to document the past work history of the employees. The work history of these four operatives revealed three operatives had worked in the cotton industry with 1 year, 2 years and 34 years of cotton exposure respectively. As only 1 operative reported byssinotic symptoms in the blend mills subsequent analysis was performed excluding this fibre group.

Table 5 presents the basal mean FEV_1 and mean FEV_1 decline of those operatives with and without byssinosis. The mean basal measures of FEV_1 were statistically significantly lower in byssinotics compared to non-byssinotics in each fibre group. The byssinotics in the medium and waste fibre groups also exhibited greater declines in lung function compared to the non-byssinotics.

The odds ratio of developing byssinosis was greater in the medium and waste fibre groups compared to man-made fibre; MMF OR=1, Medium 7.57 (CI 2.58,22.2), Waste 14.1 (CI 4.72,41.8). The odds ratio produced by a doubling of time spent within the cotton industry demonstrated a greater than four times risk of developing byssinosis in the medium and waste mills compared to cotton. Interestingly, the odds ratio associated with a doubling of pack years of smoking and byssinosis was only significant in the waste fibre group; MMF OR=1.22 (CI 0.63,2.38), Medium 1.32 (CI 0.96,1.83) and Waste 1.54 (CI 1.07,2.22). Of the four dust parameters, only retrospective personal dust exposure significantly predicted an increase in lung function decline (PDPAST). The odds ratio of a doubling PDPAST demonstrated a greater than 4 times the risk of developing byssinosis in the medium and waste fibre groups compared to mammade fibre.

Summary

This provisional analysis has documented rates of lung loss, in each of the fibre groups, which are consistent with the rates of lung function decline observed in prospective studies of normal populations. However, the pattern of lung function decline varied across each exposure group. Greater declines were found in those operatives processing man-made fibre and waste cotton. The reason for this is unclear and it may be multi factorial. Within the man-made fibre group, over half of the population have had past exposure to cotton. The basal measures of lung function were also statistically lower in this group compared to those in the waste exposed group. It is possible that susceptible workers are self-selecting from the more acutely toxic environment of cotton mills, and the excess decline is spurious because of a selected "unhealthy" worker concentration within the man-made fibre sector. Alternatively as witnessed in similar epidemiological studies there may be a chronic effect of man-made fibre exposure on lung function.

Within the cotton exposed group, the waste mills have the highest levels of dust and contaminants, and this may be a true exposure response relationship. Lung function decline was also associated with length of time exposed in the cotton industry and also cumulative dust exposure, supporting this theory.

The overall low level of decline may exist as susceptible workers select out at an early stage and a relative "survivor" population is left.

With regard to byssinosis, this is still associated with an increased cumulative exposure to dust and length of time working in the cotton industry. Individuals with byssinosis, have a higher rate of lung function decline than their non-byssinotic counterparts.

In conclusion, rates of lung function decline are low overall, but a dose response relationship exists within the cotton cohort. The cause of the higher decline in man-made fibre exposed workers remains uncertain and further analysis of this data set may be helpful in clarifying the aetiology of this finding.

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Table 1. Study population over five years.

	Year 1	Year 2	Year 3	Year 4	Year 5
6 Cotton Mills					
Target population	640.00	648.00	613.00	620.00	622.00
Sample population	553.00	558.00	508.00	492.00	517.00
Response rate	86.5%	86.1%	82.8%	79.3%	83.1%
2 MMF Mills					
Target population	486.00	475.00	501.00	474.00	442.00
Sample population	438.00	427.00	410.00	367.00	348.00
Response rate	90.1%	89.9%	80.1%	77.4%	78.7%

Table 2. Demographic feature of each fibre group.

	MMF 569	Blend 202	Medium 413	Waste 210
Female	38.8%	47.0%	26.6%	24.3%
Caucasian	60.5%	88.6%	68.5%	66.7%
Asian	38.8%	11.4%	29.3%	30.0%
Mean age (CI)	42.0yrs (41.1-42.8)	44.3yrs (42.7-45.8)	45.8yrs (44.7-46.9)	43.2yrs (41.7-44.8)
Median pack yrs (range)	0.3 (0-92)	10.5 (0-48)	8.5 (0-150)	7.8 (0-85)

Table 3. Median (range) personal, work area and retrospective cotton dust exposures expressed in mg/m^3.

	MMF	Blend	Medium	Waste
PD	no exposure	0.75 (0-4.2)	0.94 (0-16.5)	3.79 (0-21.1)
PDPAST	2.6 (0-128.5)	23.4 (0-566)	22.8 (0-269)	34.9 (0-269)
SD	no exposure	0.15 (0-0.37)	0.47 (0-2.5)	1.52 (0-5.6)
SDPAST	1.5 (0-37.4)	7.5 (0-29.7)	11.2 (0-39.8)	15.2 (0-50.4)

Table 4. Overall mean baseline measures of lung function, FEV_1 and FVC, and mean rate of ung function decline values (CI).

	MMF	Blend	Medium	Waste
Baseline FEV_1 litres	2.93 (2.85,2.99)	3.08 (2.96,3.20)	2.89 (2.80,2.98)	3.12 (3.00,3.24)
Rate of decline mls/yr	-17 (-25,-9)	4 (-6,14)	-5 (-17,7)	-21 (-33,-9)
Baseline FVC litres	3.63 (3.54-3.72)	3.91 (3.77-4.06)	3.73 (3.63-3.85)	4.01 (3.87-4.15)
Rate of decline mls/yr	-11 (-19,-3)	4 (-15,-9)	-5 (-17,7)	-20 (-34,-6)

Table 5. Mean baseline measures and lung function decline of FEV_1 in byssinotics and non-byssinotics in each fibre group (CI).

	Non Byssinotic		Byssinotics	
	FEV_1 litres	Decline Mls/yr	FEV_1 Litres	Decline mls/yr
MMF	2.93 (2.86,2.99)	-17 (-25,-9)	2.61 (2.55,2.68)	-1 (-67,65)
Medium	2.92 (2.83,3.02)	-1 (-11,9)	2.25 (1.94,2.55)	-24 (-55,7)
Waste	3.17 (3.04,3.29)	-19 (-33,-5)	2.65 (2.26,3.03)	-45 (-70,-20)