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Respiratory disability in ex-flax workers

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ABSTRACT Acute respiratory effects occur in a high proportion of subjects exposed to textile dusts. The extent to which these lead to permanent respiratory symptoms and loss of lung function is unknown. A survey of random population samples was therefore conducted in ten towns in Northern Ireland in which flax processing had been a major source of employment. The MRC questionnaire on respiratory symptoms was administered and Vitalograph tracings recorded on subjects aged 40 to 74 inclusive. An occupational history was taken at the end of each interview. Lung function in ex-flax workers was slightly lower than in control subjects never exposed to flax dust, but the presence of a positive interaction with age meant that differences were apparent only in the younger subjects. Over about the age of 65 the lung function in the ex-flax workers was comparable with that of the controls and overall the loss was at most about half that due to light smoking (1–14 cigarettes a day). The association between a "dust exposure score" and lung function was inconsistent in the two sexes. In men there was a small decrement with increasing dust exposure. In women there was also a small decrement, but a positive interaction with age meant that the women with the highest dust exposure scores had a lower loss with increasing age than the women with the least dust exposure. There was an excess in symptoms in the ex-flax workers but the size of the excess was greater than would be expected from the lung function results. It is possible that, although the survey was conducted without explicit reference to the flax industry, knowledge throughout Northern Ireland that many flax workers have been awarded compensation on the grounds of respiratory disablement may have led to an increased reporting of symptoms in the ex-flax workers.

For many years the processing of flax and the weaving of linen has been an important industry in Northern Ireland, second only to agriculture, but its future is at present uncertain.[1] On the one hand, the rise in the price of synthetic fibres, together with the development of new methods of processing flax and new uses for linen, could lead to an expansion of the industry at all stages, including the growing of the flax plant. On the other hand, claims that flax dust has harmed their health are being made by increasing numbers of workers and ex-workers and large settlements are being demanded in compensation. It is currently estimated that unsettled claims represent a total of at least £16m. Northern Ireland is an economically depressed area and the preservation of any industry is important.

Several developments in the industry are of particular interest. Firstly, substantial efforts have been made to lower dust levels in flax mills and monitoring has shown a fall in the average levels in the early prepreparing stages, hackling and carding, two of the most dusty processes, from mean values of about 600 and 1000 mg/100 m^3 respectively in 1961[2] to about 300 and 150 mg/100 m^3 respectively in 1980.[3] Secondly, a method of dry retting by spraying the flax plant with a desiccating chemical a few weeks before harvesting has been developed, and experimental work has shown that dust from plants so treated has a much smaller acute effect on respiratory function than has dust from conventionally wet retted plants (JP Jamieson *et al*, paper read at New Light on Byssinosis conference, Cardiff, 22 February 1985).

Schilling was the first to conduct epidemiological surveys in textile workers in Lancashire[4,5] and Pemberton and co-workers later studied flax workers in Northern Ireland using similar methods.[2,6–9] In both

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industries the prevalence of byssinosis is closely related to the dust levels in the environment. Pemberton *et al* in 1961–2 found that over 50% of workers in dusty prepreparing occupations had symptoms, though the prevalence was much lower in other occupational groups.[6 9]

Elwood *et al*, having carefully examined the whole epidemiological picture, considered that flax dust seems to have an acute, reversible, specific effect on the respiratory system of all exposed subjects, and they suggested that this effect is "greater, or more noticeable in workers whose respiratory tract is irritated or whose lung function is impaired by conditions such as chronic bronchitis" and so the symptoms of byssinosis are much more likely to develop in these subjects.[7] Such a view is consistent with the much higher prevalence of byssinosis in smokers than in non-smokers and it would also explain the close association between the occurrence of byssinosis and chronic bronchitis in the same subject.[7]

This evidence is consistent with the hypothesis that byssinosis is an acute and reversible response to the dust by the respiratory system. Such an effect on exposed workers is important and may be decisive to their continued employment as is acknowledged by the definition of flax workers' byssinosis as a prescribed disease under the Industrial Injuries Act (1965). The question of permanent respiratory disability is quite a different issue, however, and if this does occur it is far more important than any acute, reversible effect.

The evaluation of long term effects is difficult, and clinical impressions can be quite misleading because of the relatively high prevalence of respiratory symptoms and respiratory disability in the community. For example, the prevalence of asthma in the general population is around 5–6%,[10 11] and the prevalence of chronic bronchitis is not only high but shows an increase with age. Lowe *et al* reported a prevalence of 14% in men aged 35–44 and 26% at 55–64.[12] Although there is about a threefold difference between the prevalence of chronic bronchitis in smokers and non-smokers, it does occur in non-smokers. For example, Lowe *et al* found a prevalence of 6% in men aged 35–44 who had never smoked, rising to 8% at 55–64. Furthermore, 4% of men aged 35–44 and 11% of men aged 55–64 had dyspnoea on effort without the hypersecretion of chronic bronchitis. Against this background, the attributing of respiratory symptoms, or disablement, to any one particular cause will be difficult.

Because of the uncertainty of the evidence relating to permanent disability in textile workers, and because of the importance of this question to the future of the textile industry, two surveys were conducted, one based on ex-flax workers in Northern Ireland, the other on ex-cotton workers in Lancashire. This report describes the survey of ex-flax workers, the survey of ex-cotton workers is described elsewhere (PC Elwood *et al*, in preparation).

Methods

Ten towns within the Province of Northern Ireland in which the processing of flax had been a major source of employment were selected. Belfast and Londonderry were omitted because population movement was high in these cities and the tracing of subjects would have been difficult. Random samples of electors were drawn within each of the towns. The aim was to examine an eventual sample of 200–300 subjects within the restricted age range (40–74) within each town and therefore random samples of 600 names were selected, though in several towns there were insufficient electors to yield this total.

Each subject was written to and then visited at home. If within the age range 40–74 a questionnaire, which included the MRC respiratory symptom questionnaire was administered, three Vitalograph tracings were recorded, and an occupational history obtained. Every effort was made to maintain a high response rate. No mention of an interest in the flax industry was made, however, and the work was referred to simply as a "health survey."

Apart from within Belfast, which is a major industrial city, the only industry in Northern Ireland with a dust problem is the flax industry. Subjects were therefore divided into those who had worked in the flax industry for at least one year and those who had not. To avoid confounding of the acute effect of exposure to flax dust with any permanent respiratory effects, all current workers were excluded. An exposure score was derived for each subject: this is the sum of the products of the durations within three groups of jobs in the industry and a dust score for that job. Jobs were grouped qualitatively at four levels to correspond to dustiness. In brief, jobs in the "prepreparing" stages of the processing of flax were graded as "dust level 3" and jobs in "preparing" were graded 2. All other jobs in the industry, including weaving, were graded 1, except for wet spinning which was graded 0. Definitions of prepreparing, preparing, etc are given elsewhere[6] as are details of dust concentrations throughout the industry.[2 3]

The Vitalograph tracings were later read blind with regard to previous occupation, etc. Forced expiratory volume in one second (hereafter FEV_1) and forced vital capacity (FVC) were noted. For analysis FEV_1 and FVC were taken as the mean of the two highest readings provided that these did not differ by more than 0·3 litre. If they did so differ then the highest reading was used. The position of the subject when performing the manoeuvre, whether sitting or standing, was noted. Statistical analysis was based on the model proposed by Cole in which lung function varies linearly with age but is proportional to height.[13] Thus we analysed FEV_1 or FVC × $(1\cdot70/Ht)^2$ for men and FEV_1 or FVC × $(1\cdot58/Ht)^2$ for women, 1·70 and 1·58 being the overall mean heights in metres respectively. Multiple linear regression as implemented in the computer package GENSTAT was used.

A six point classification of smoking habit was used. Non-smokers were those who had never smoked cigarettes, pipe, or cigars for as much as one year. Ex-smokers were those who had smoked one or more cigarettes a day in the past but did not do so now. Pure pipe and cigar smokers were separately classified. Current smokers were classified by their present cigarette consumption: 1–14, 15–24, or 25 or more a day.

Results

The number of subjects seen in the survey was 2129, 90% response rate of those eligible for inclusion. Of these, 88 current flax workers were excluded. A further 111 subjects were excluded from the analyses of lung function because there were no lung function test results. In most cases these subjects had refused to cooperate fully but for some no suitable source of electricity for the Vitalograph had been available in the home. The results for a further 33 subjects were excluded from the lung function analysis because the Vitalograph tracings, evaluated without reference to the industrial history of the subjects, clearly indicated that expiratory effort had been poor and that either the volume recorded rose slowly, or was still rising at the end of the trace. One subject was excluded because of an incomplete questionnaire. Table 1 shows the distribution of the 1896 remaining subjects by age, sex, and exposure.

Table 2 shows the mean heights of various subgroups of subjects. The ex-flax workers were 1–2 cm shorter than the control subjects, and although height is allowed for in the regression analyses that follow, these differences suggest that there may have been selection of workers into the industry.

The regression of lung function, FEV_1 and FVC, adjusted for height, is summarised in table 3. The model explains, within the four sex x function subgroups, from 32% to 39% of the total variance in lung function. There is a highly significant decline in FEV_1 and FVC with age and with increasing cigarette or tobacco consumption, this last being somewhat greater on FEV_1 than on FVC. Standing subjects produced a slightly larger FEV_1 or FVC than sitting subjects. The effect of past exposure to flax dust is complicated by a positive interaction between exposure and age. This has the effect of reducing the effect of past exposure considerably with increasing age. In an analysis of all the data, with sex included as a factor, the interaction term is significant, but within the sexes analysed separately (as shown in table 3) the interaction is significant at $p < 0\cdot05$ only in women. There was no evidence of a significant interaction between age and smoking.

In Table 4 are set out predicted lung function levels at two ages, based on the regressions in table 3. At age 40 the levels are lower in the ex-flax workers by 5–11% but this difference becomes progressively less in subjects of increasing age and at age 74 there is a small but non-significant excess in the lung function of the ex-flax workers (figs 1 and 2). Table 4 also sets out the results of a regression of FEV_1 as a percentage of FVC within each subject. Again lower levels are apparent only in the younger subjects and even in the youngest the differences are trivial.

Table 2 *Mean heights (m) in various subgroups of subjects*

	Age (years)		
	(40–54)	*(55–64)*	*(65–74)*
Men:			
Ex-flax workers	1·71	1·70	1·68
Never exposed to flax	1·72	1·71	1·69
Women:			
Ex-flax workers	1·58	1·57	1·55
Never exposed to flax	1·60	1·59	1·57

Standard deviation of height is about 0·07 m.

Table 1 *Sample by age, sex, and dust exposure. Numbers shown are those for whom lung function data are available. (Numbers included in tables 6 and 7 are slightly larger)*

	Age (years)			
	40–54	*55–64*	*65–74*	*Total*
Men:				
Ex-flax workers	130	65	58	253
Never exposed to flax	310	182	152	644
Total	440	247	210	897
Women:				
Ex-flax workers	135	119	122	376
Never exposed to flax	304	173	146	623
Total	439	292	268	999
Grand total	879	539	478	1896

Fig 1 *Predicted values of FEV_1 by age in men and women, ex-flax workers, and control subjects never exposed to flax dust.*

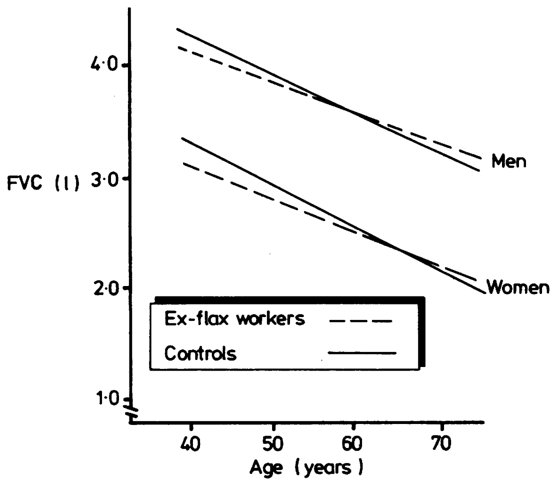

Fig 2 *Predicted values of FVC by age in men and women, ex-flax workers, and control subjects never exposed to flax dust.*

Table 3 *Regression coefficients for FEV_1 and FVC† (l) on age, smoking habit, position, and exposure*

	FEV_1		*FVC*	
	Men	*Women*	*Men*	*Women*
Constant	5·74	4·39	6·65	5·14
Age	−0·048***	−0·040***	−0·048***	−0·043***
Ex-smokers‡	−0·29**	−0·09	−0·16**	−0·02
Light	−0·28**	−0·12**	−0·11	−0·03
Medium	−0·43**	−0·23**	−0·18**	−0·15**
Heavy	−0·50**	−0·26**	−0·26**	−0·18
Standing§	0·15*	0·09	0·18*	0·09
Exposure‖	−0·48*	−0·69**	−0·54*	−0·64**
Exposure Age¶	0·007	0·010**	0·008	0·010**

*$p<0·05$, **$p<0·01$, ***$p<0·001$.
†FEV_1 and FVC standardised to overall mean height (see text).
‡All smoking categories compared with non-smoking.
§Standing compared with sitting.
‖Ever exposed to flax dust compared with subjects never exposed to flax.
¶Interaction between ever exposed to flax dust and age.

Table 4 *Mean predicted FEV_1 and FVC (l) for sitting, non-smoking subjects of average height, at ages 40 and 74. The differences (ex-flax workers—never exposed) shown as l and as percentages of the values in the never exposed subjects*

	At age 40			*At age 74*		
	FEV_1	*FVC*	*FEV%**	*FEV_1*	*FVC*	*FEV%**
Men:						
Ex-flax workers	3·62	4·50	82%	2·22	3·16	71%
Never exposed	3·82	4·73	83%	2·19	3·10	70%
Difference	−0·20	−0·23	−1%	+0·03	+0·06	+1%
	(−5%)	(−5%)		(+1%)	(+2%)	
Women:						
Ex-flax workers	2·49	3·18	79%	1·47	2·05	73%
Never exposed	2·79	3·42	83%	1·43	1·95	73%
Difference	−0·29	−0·24	−4%	+0·05	+0·10	—
	(−11%)	(−7%)		(+3%)	(+5%)	

*FEV_1 expressed as % of FVC in each subject.

The dust scores were examined in detail. Substituting these for "exposure" in the regressions summarised in table 3 yielded slopes for FEV_1 and FVC respectively on dust score in men of −0·0036 SE 0·0016 and −0·0042 SE 0·0016. Thus there is a small and significant effect of dust in men. In women the same effect is again small but not statistically significant (+0·0015 SE 0·0011 and +0·0013 SE 0·0012 for FEV_1 and FVC respectively). These effects, however, are difficult to interpret because there is a significant positive interaction between dust exposure score and age (0·00035 SE 0·00013 and 0·00029 SE 0·00015 for FEV_1 and FVC respectively). Table 5 therefore presents the predicted lung functions at two extreme ages. As would be expected from table 3 and the figures, a possible effect of dust exposure on lung function is somewhat greater at the younger age, especially in women. Again, therefore, these data give little support to a progressive and irreversible effect of dust on lung function.

The association between past exposure to flax dust and chronic bronchitis (production of phlegm on most mornings for at least three months for the past two years) is shown in table 6. These data have not been standardised for age and whereas the age distribution of ex-flax workers and controls are similar in men the female ex-flax workers are somewhat older than their controls (table 1). Among the ex-flax workers there is a considerable excess in these symptoms, particularly in the non-smokers. The data for breathlessness, MRC grades 2 and 3, show a pronounced excess in the ex-flax workers, especially in the non-smokers (table 7).

Discussion

The view that *irreversible* damage is caused in the respiratory system of textile workers is widespread.[14–17] Furthermore, the operation of industrial injuries legislation implies that permanent effects

Table 5 *Effect of the dust exposure score: mean predicted FEV_1 and FVC (l) for sitting, non-smoking subjects of average height, at ages 40 and 74*

	At age 40		*At age 74*	
	FEV_1	*FVC*	*FEV_1*	*FVC*
Men:				
Dust score				
0	3·80	4·69	2·24	3·06
1–20	3·68	4·48	2·41	3·32
21–40	3·84	4·68	1·95	2·88
>41	3·43	4·24	2·11	2·94
Women:				
Dust score				
0	2·73	3·37	1·40	1·94
1–20	2·51	3·16	1·38	1·95
21–40	2·40	3·12	1·61	2·14
>41	2·23	2·87	1·54	2·10

The dust score is, for each subject, the sum of the product of years spent in jobs in the flax industry and dust scores for these jobs (see text). For ease of presentation these have been grouped as above.

Table 6 *Percentages of subjects (and numbers affected) with chronic bronchitis by sex and smoking category*

	Men		*Women*	
	Ex-flax workers	*Never exposed*	*Ex-flax workers*	*Never exposed*
Non-smokers	18·6 (8)	6·3 (10)	16·0 (35)	4·7 (18)
Ex-smokers	16·7 (12)	14·3 (29)	21·0 (9)	10·4 (8)
Light	40·3 (21)	16·5 (15)	36·0 (19)	7·9 (6)
Medium	36·7 (22)	27·3 (33)	21·0 (12)	13·7 (10)
Heavy	44·4 (16)	34·9 (30)	27·8 (5)	33·3 (6)

Subjects with FEV_1 etc missing are included in this and in table 7.

Table 7 *Percentages of subjects (and numbers affected) with breathlessness grades 2 and 3 by sex and smoking category*

	Men		*Women*	
	Ex-flax workers	*Never exposed*	*Ex-flax workers*	*Never exposed*
Non-smokers	16·7 (7)	7·3 (11)	22·7 (47)	9·1 (33)
Ex-smokers	21·7 (15)	19·4 (37)	39·0 (16)	19·2 (14)
Light	26·9 (14)	15·5 (14)	45·3 (24)	10·7 (9)
Medium	25·0 (14)	12·5 (15)	21·4 (12)	11·4 (8)
Heavy	8·3 (3)	18·3 (15)	12·5 (2)	11·1 (2)

occur in byssinosis as with the pneumoconioses due to coal, slate, and asbestos dust. It has also been accepted at common law in the United Kingdom that respiratory disablement from exposure to cotton dust occurs as in other lung diseases in which awards have been made.

It must be recognised, however, that little relevant evidence on the permanent effect of exposure to textile dusts exists. Almost all the published work has been done on workers in the industry and most inquiries have been conducted within working mills. To extrapolate from current workers to subjects who have retired or left the industry is invalid. Undoubtedly permanent respiratory disability does occur in any group of workers, be they in the flax or any other industry, but the extent to which the disability that is observed in selected textile workers is simply asthma or chronic bronchitis, unrelated to flax dust, is unknown and can be ascertained only from epidemiological surveys such as we now present.

There are several reasons why irreversible effects are unlikely. The only feature with is characteristic of byssinosis is the periodicity of the symptoms within the working week, and there are no biochemical, radiological, or pathological changes shown to occur in byssinosis, nor is there evidence of any decrease in survival[18 19] (SM Daum *et al*, paper given at XVII International Congress on Occupational Health, Brighton, 1975). All this contrasts with the progressive changes in the lungs of workers with pneumoconiosis that may be detected radiologically or at necropsy even before disability can be detected clinically, and before there is any increased risk of death.[20-22]

Our survey was set up to examine whether or not subjects who in the past had been exposed to flax dust give evidence of any impairment in lung function or increase in respiratory symptoms, or both, and, if these effects do occur, to estimate their severity. The work was conducted in close collaboration with a closely similar study based on ex-cotton workers in two towns in Lancashire. (PC Elwood *et al*, in preparation).

The inquiry was based on random samples of ex-flax workers and on random samples of subjects from the general population in the same towns and a high response was achieved. One of the basic requirements of epidemiology was therefore fulfilled in that the study was conducted on representative samples of the population subgroups of interest. On the other hand, it could be argued that the omission of any subjects limits the confidence that can be put in the conclusions. This is especially true in respiratory surveys as it has been shown that subjects who had been omitted from a study because of non-repeatable tests of lung function subsequently lost FEV_1 faster than other subjects.[23] It is important therefore to note that we did not include any repeatability criterion such as those recommended by Oldham[24] and others,[25] and all subjects who had at least one technically acceptable Vitalograph tracing of FEV_1 or FVC, or both, were included in the analysis. Furthermore, the numbers of ex-flax and control subjects in whom no Vitalograph tracing was judged acceptable (16 or 2·5% and 17 or 1·3% respectively) are small and do not differ significantly ($\chi^2 = 2{\cdot}76$, $p > 0{\cdot}10$).

The extent to which the observations made were free from bias is difficult to judge. Every reasonable attempt was made in the survey to eliminate bias. The survey was said to be a health survey, and no mention of the flax industry was made nor any mention of either the academic department or the research workers who had been associated with earlier surveys in the industry. Occupational details were obtained from each subject at the end of the interview—that is, after the symptom questionnaire had been completed and lung function tests performed. Nevertheless, there is considerable awareness of byssinosis throughout Northern Ireland and this has been heightened recently with the financial settlement of many claims of disablement from past employment. The extent to which this awareness increased the reporting of respiratory symptoms by ex-flax workers is unknown. The fact that a large part of this excess of symptoms arose in the part of the Province from which most of the claims for compensation have originated[26] makes it seem likely that there was considerable over-reporting. The field workers stated that the level of co-operation by some subjects who at the end of the interview turned out to have been flax workers appeared to have been less than desirable. Whereas such statements can be given little weight, the fact that the proportion of subjects for whom no lung function tests are available, mostly because of refusal to cooperate, is three times higher in the ex-flax workers than in the controls is consistent with the statements of the field team.

Indeed, doubts about the validity of the symptom data for the ex-flax workers arise from the fact that in other studies the symptoms of chronic bronchitis and dyspnoea are associated with a pronounced impairment in lung function[10 26 27] whereas in the present data there is a disparity between the large excesses in symptoms and the relatively small decrements in lung function. Further evidence comes from a comparison with the survey of ex-cotton workers (PC Elwood *et al*, in preparation) where there is probably much less awareness of byssinosis and where few workers have so far claimed financial compensation for disablement. There the ex-cotton workers showed no excess in the symptoms of chronic bronchitis and only a small excess in dyspnoea.

Because of this possible overreporting of symptoms it is probably better to draw conclusions from the lung function data. The presence of a positive interaction between age and past dust exposure, however, makes it difficult to draw firm conclusions. The direction of this interaction is unexpected. Had exposure to flax dust a permanent effect, then one would expect that the older workers, who will have had, on average, long durations of employment, and whose exposures will have been in the past when dust levels were high, to show a greater loss in lung function than younger workers whose exposures will have been shorter and to lower dust levels. Consequently, a negative interaction would have been expected between "exposure" and age.

There are several possible explanations for this positive interaction between age and dust exposure. We think it unlikely that it could be a consequence of an increased mortality in the exposed subjects as a follow up of a large cohort of flax workers gave no evidence of any such excess.[19] The most likely explanation seems to us to be selective recruitment of the less fit into the flax processing industry. This selection may have become more pronounced in recent years with the diversification of industry in the Province and increased opportunities for employment in jobs other than flax processing.

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