THE EFFECT OF VEGETABLE DUST ON RESPIRATORY FUNCTION OF INDUSTRIAL WORKERS

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I. Introduction

Although a great many papers have been published on byssinosis and related subjects, the whole syndrome of byssinosis is still far from being definitely elucidated. Byssinosis is an industrial pulmonary disease which affects certain groups of workers exposed to certain types of airborne vegetable dust. In spite of the fact that it was Ramazzini himself, years ago, who described a typical respiratory disease of textile workers, the very existence of byssinosis is still disputed in many circles. Today it is only the cotton-caused byssinosis that is generally accepted as an occupational disease and even included in the list of compensable occupational diseases in a few countries, while byssinosis caused by other vegetable dusts, such as hemp and flax, has not yet received general recognition.

The diagnostic basis of byssinosis is not yet definitely defined. Byssinosis is characterized by symptoms of chest tightness, cough, wheezing and shortness of breath, usually accompanied by the acute reduction of ventilatory lung capacity during the work shift (1). The symptoms are by far most evident on the first day after absence from work, particularly so at the initial stages of the disease, while on the following days they may not be felt at all. Some authors claim that there is no acute reduction of ventilatory capacity during the work shift except on first exposure to dust after absence from work (Monday effects). As there are no radiological changes specific to byssinosis at the early stages of the disease, the early diagnosis is most often based upon the characteristic Monday symptoms and, far less often, on the basis of acute reduction of ventilatory capacity, particularly the timed forced vital capacity. In later stages the clinical picture of byssinosis is in fact identical to that of chronic bronchitis or emphysema so that it is impossible to differentiate between these diseases except on the basis of the past occupational history.

The etiopathogenesis of byssinosis is not yet clarified either. There have been indications that there may be some biologically active agents (bronchoconstrictors) contained in certain vegetable dusts that affect smooth muscles of bronchi, and of bronchioles in particular, producing, in this way, a spastic reduction of ventilatory capacity (2). As the content of these contractor substances in airborne vegetable dust has generally been found too low to account for the very significant acute reductions of ventilatory capacity, it has been proposed that it is some agents contained in vegetable dust that release histamine from lung tissue, thus causing, in this indirect way, a histamine-produced contraction of smooth muscles in the respiratory system (3).

There is still some dispute on whether the term byssinosis should be used to describe the reversible condition caused by the acute effects of vegetable dusts or the irreversible pathological condition developing after chronic exposure to active vegetable dusts through a longer period of time (as a rule, after at least 8-10 years of exposure). It may not be unreasonable to accept the former definition which results in an earlier diagnosis of the disease and allows the prevention of the development of its chronic stages.

There are three main objectives of the present study:

1. To verify whether cotton, flax, hemp, and jute dust should be considered as byssinogenic and to establish the relative potency of these dusts to the reduction of ventilatory capacity and development of non-specific respiratory disease.

2. To study the preventive and curative effects of bronchodilators and possibly antihistaminics in workers exposed to vegetable dusts.

3. To attempt the isolation and identification of biologically active agents contained in airborne dusts and to develop methods for the quantitative or at least semi-quantitative assessment of the contraction potency of these agents.

II. Methods

Dust Assessment

Airborne dust samples are collected by means of a modified Hexhlet apparatus and the dust concentrations are determined in two particle size groups; the total dust fraction and the respirable dust fraction.

Respiratory Symptoms

Respiratory symptoms are recorded by using the British Medical Research Council questionnaire (4) completed with some questions relating to such characteristic symptoms of byssinosis as the chest tightness or breathlessness on Monday and effort intolerance (5).

Lung Function Tests

The one-second forced expiratory volume ($FEV_{1.0}$), the forced vital capacity (FVC) and in some cases the peak expiratory flow (PEF) are determined before and after the work shift on Mondays and Thursdays. The lung function tests are carried out by the Bernstein type spirometers. Five measurements are performed in each subject during each spirometric examination, and the highest value is taken as the result of the test.

The measurements also include basic anthropometric parameters measured in each subject (standing height, sitting height, and body weight).

Byssinosis is diagnosed on the basis of the following:

1. Established exposure to vegetable dust.

2. Chest tightness and breathlessness on Mondays and/or other days in the week.

Byssinosis is graded as described by Shilling, Vigliani, Lammers, Valić and Gilson (6):

Grade 1/2 - Occasional chest tightness on the first working day of the working week.

Grade 1 - Chest tightness on every first day of the working week.

Grade 2 - Chest tightness on the first and other days of the working week.

Grade 3 - Grade 2 symptoms accompanied by evidence of permanent incapacity from effort intolerance.

Chronic bronchitis is diagnosed on the basis of the definition proposed by Fletcher et al (7), i.e., as "a condition characterized by a productive cough on most days for at least three months in the year during at least two consecutive years, provided other pulmonary diseases have been excluded."

Dyspnea is recorded on the basis of the recommendations of the Medical Research Council's Committee on the Etiology of Chronic Bronchitis (7).

III. Population

The results are presented of the studies on 102 female workers exposed to hemp dust, three samples totalling 184 female workers exposed to cotton dust (Mill A - 70, Mill B - 53, and Mill C - 60), 92 female workers exposed to jute dust, and 30 female workers exposed to flax dust.

All the workers were chosen among non-smokers.

IV. Results

Hemp Exposure

Prevalence of byssinosis, persistent cough, persistent phlegm and dyspnea (Grade 2 and 3) with corresponding mean dust concentrations are summarized in Table 1. Of 102 female hemp workers 39 percent had symptoms of byssinosis similar to those found in the previous studies (8), carders: 49 percent, spinners: 32 percent, difference not significant). No significant difference was found between carders and spinners in prevalence of any respiratory symptoms except for persistent cough which was higher in carders ($p < 0.05$). Younger and older workers, with short and long durations of exposure, had symptoms of byssinosis. Subjects with byssinosis had significantly higher prevalence ($p < 0.01$) of persistent cough (78 percent), persistent phlegm (65 percent), dyspnea (38 percent) and chronic bronchitis (56 percent) than those without byssinosis (37, 31, 26, and 30 percent respectively) (Table 2). Of eight workers exposed to hemp dust for about a year, four had characteristic symptoms of byssinosis. Of 39 byssinotics, 16 had byssinosis Grade 1/2, 15 Grade 1, and 8 Grade 2. As is seen in Table 2, prevalences of all respiratory symptoms (persistent cough, persistent phlegm, dyspnea, chronic bronchitis) were significantly higher in hemp workers than in controls irrespective of simultaneous development of byssinosis.

To assess the acute effects of hemp bust on ventilatory function, changes in $FEV_{1.0}$ and FVC during the work shift were measured (Table 3). While no changes were recorded in control workers either in $FEV_{1.0}$ or FVC, both parameters decreased significantly ($p < 0.01$) in both byssinotic and non-byssinotic hemp workers on Mondays and Thursdays (with the exception of Thursday FVC in byssinotics). The reductions of ventilatory parameters were significantly higher on Mondays than on Thursdays ($p \leq 0.01$). The mean Monday $FEV_{1.0}$ reduction was found significantly greater in byssinotics than in hemp workers without byssinosis ($p < 0.01$). This, however, was not the case on Thursdays.

In Tables 4 and 5 the effects of Alupent* inhalation before and after the work shift are presented. In the first week Alupent was administered to 44 female hemp workers on Monday at the end of the shift after lung function testing. As is shown in Table 4, the significant $FEV_{1.0}$ reduction during the shift proved to be reversible to a great extent by the administration of the bronchodilator. In fact, the mean $FEV_{1.0}$ was increased to its initial pre-shift values after the inhalation of Alupent with the exception of $FEV_{1.0}$ in byssinotics in whom the mean $FEV_{1.0}$ value remained significantly lowered in spite of the bronchodilator application. The acute effect of hemp dust inhalation in byssinotics appears to have been so strong that the administration of the bronchodilator, in spite of a significant increase of $FEV_{1.0}$, could not reverse it to its pre-shift value.

The effects of the Alupent administration before the shift are shown in Table 5. Alupent produced no change in the normal $FEV_{1.0}$ measured before exposure to hemp dust. Repeated measurements of ventilatory function the same day after the work shift showed that the inhalation of the bronchodilator before the shift decreased the reduction of $FEV_{1.0}$ during the shift. The difference between the $FEV_{1.0}$ values measured before and after the shift, in the case of Alupent administration before the shift, was, however, still significant both in byssinotic and non-byssinotic hemp workers. The application of the bronchodilator before the shift did significantly diminish the reduction of ventilatory function though not completely preventing it.

In order to assess the possible chronic effects of hemp dust on ventilatory function, a comparison was made of the values of $FEV_{1.0}$, FVC, and $FEV_{1.0}$/FVC percent obtained on Mondays before the shift in workers exposed to hemp dust and in the controls. The subjects in the control groups were selected in such a way as to almost fully match the respective exposed groups (byssinotics and non-byssinotics) in the age and height distribution. It has been assumed that the changes of ventilatory capacities in the exposed groups on Mondays before the shift, prior to the superposition of acute effects of exposure to hemp dust during the work shift, represent chronic changes in ventilatory function due to the long-term exposure to hemp dust. As can be seen from the results presented in Table 2 all three ventilatory function parameters were found significantly lower ($p < 0.01$) in subjects exposed to hemp dust than in the controls, except for FVC in byssinotics.

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* Orciprenaline: 1-/3,5-dihydroxyphenyl/-2-isopropyl aminoethanol sulphate.

Cotton Exposure

The results of the determination of the airborne cotton dust in cotton mill A are presented in Table 6. The concentrations are expressed as total dust and as respirable dust, the latter being defined as the particle size fraction that passes the Hexhlet horizontal laminar plate elutriator which conforms to the requirements of the British Medical Research Council for the particle retention in the upper respiratory tract (9). As can be seen from Table 6, the mean total dust concentration was very high.

The prevalence of chronic bronchitis and dyspnea (Grade 3 and 4) is shown in Table 7. Not a single case of byssinosis was registered among the examined workers in spite of the comparatively very high mean total dust concentration. Fourteen percent of the examined female workers had symptoms of chronic bronchitis and eighteen percent suffered from dyspnea Grade 3 or 4.

Mean $FEV_{1.0}$ and FVC changes over work shift measured in the group of 70 female cotton workers are shown in Table 8. Comparatively small but significantly ($p < 0.01$) reductions of $FEV_{1.0}$ and FVC were measured on the first day after Sunday break. The reductions were significantly smaller on Thursdays than on Mondays.

As seen from the Table 9, the mean total dust concentration in Mill B was considerably lower than in Mill A, while the mean respirable dust concentrations were similar in both mills.

The prevalence of byssinosis in workers of Mill B was found to be 20.8 percent. The prevalence of chronic bronchitis was 54.5 percent in byssinotic and 26.1 in non-byssinotic cotton workers, while the prevalences of dyspnea Grade 3 and 4 were 18.1 and 2.4 percent respectively (Table 10).

In spite of the lower mean total dust concentration in Mill B, Monday and Thursday $FEV_{1.0}$ and FVC changes over shift in workers from that mill were much more pronounced than in workers from Mill A (Table 11).

The falls of both ventilatory parameters were statistically significant on Mondays and Thursdays in byssinotic and non-byssinotic cotton workers of Mill B (Table 12). The reductions were greater in byssinotics than in non-byssinotic workers but these differences were not significant ($p > 0.05$), which can probably be explained by the comparatively small number of the workers involved.

Dust concentrations measured in cotton mill C are presented in Table 13. The mean dust concentrations, both total and respirable, were similar to those measured in cotton mill B and the respirable dust concentration did not differ much from that measured in cotton mill A. In spite of the almost three times lower mean total dust concentration as compared with that in cotton mill A, the prevalence of byssinosis was found to be 28.3 percent (Table 14). The prevalence of both chronic bronchitis and dyspnea was higher in byssinotics than in non-byssinotics.

Changes in ventilatory function values over shift in female workers employed in cotton mill C are presented in Table 15. The changes in $FEV_{1.0}$ and PEF were significantly higher on Mondays than on Thursdays ($p < 0.05$). Mean reductions of all ventilatory parameters over shift were higher in byssinotics than in non-byssinotics but the differences were not found to be statistically significant, probably because of the small number of the workers examined (Table 16).

Jute Exposure

Total and respirable dust concentrations determined in a jute mill are presented in Table 17. Although neither the mean airborne total dust concentration nor the respirable dust concentration differed much from those in cotton mills B and C, no case of byssinosis was registered in workers exposed to jute dust. The prevalence of chronic bronchitis and dyspnea was very low (Table 18).

Slight but significant changes of mean ventilatory functions were observed in jute workers both on Mondays and Thursdays (Table 19). Mean changes of all the parameters were greater on Mondays. The mean length of exposure to jute dust in the examined group of workers was only 3 years.

Flax Exposure

Thirty flax workers have so far been surveyed. Their average age was 32 years and the average length of exposure 10 years. The byssinosis prevalence was found to be 40 percent and the prevalence of chronic bronchitis 47 percent (Table 20).

There was a very significant difference in the prevalence of chronic bronchitis between byssinotics and non-byssinotics (75 percent and 28 percent respectively, $p < 0.01$) (Table 21).

The results of the measurements of Monday lung function changes over shift in 30 flax workers and 60 controls are shown in Table 22. Very significant reductions of ventilatory capacities were found in flax workers while there were no changes in the control group. The control group fully matched the exposed group in height and age distribution. In fact, the subjects of the control group were selected in such a way that each subject in the exposed group had two pairs of the same body height and age in the control group.

Although byssinotics suffered from much higher reductions of ventilatory capacities over shift than non-byssinotics, the differences were not significant, this probably being due to the small number of workers in both groups (Table 23). The acute $FEV_{1.0}$ reductions were greater both in byssinotics ($p<0.05$) and non-byssinotics ($p< 0.01$) on Mondays than on Thursdays.

V. Discussion

The results obtained in non-smoking female workers exposed to airborne dust of hemp, flax, cotton, and jute give the basis for assuming that soft hemp, flax, and cotton dust may cause byssinosis. The significantly higher prevalence of symptoms of non-specific respiratory disease (chronic bronchitis, persistent cough, persistent phlegm, dyspnea) in byssinotic, than in non-byssinotic workers exposed to hemp, flax, and cotton dust suggests an association between the development of byssinosis and non-specific respiratory disease other than byssinosis. The mean length of exposure of our jute workers (3 years) was too short to allow any meaningful conclusion to the development of byssinosis.

Significant acute reductions of ventilatory parameters in workers exposed to vegetable dust on Mondays and Thursdays indicate that there is an acute effect of vegetable dusts on bronchial muscles which, although more pronounced at the beginning of the working week after the Sunday break, persists practically throughout the week. This can probably be explained by the lower depot of histamine in the lung tissue in the latter part of the week. Significant acute reductions of ventilatory capacities were found in workers exposed to vegetable dusts irrespective of whether or not they had developed symptoms of byssinosis but these reductions were, as a rule, more pronounced in byssinotics than in non-byssinotics.

In order to establish the rank of biological activity of vegetable dusts, five groups of female workers exposed to similar mean concentrations of hemp, flax, cotton, sisal*, and jute airborne dust respectively were compared as to the prevalence of byssinosis, chronic respiratory symptoms and acute $FEV_{1.0}$ and FVC changes over Monday shift. The five groups were selected in such a way as to approximately match in the distribution of age and length of exposure to the respective dust.

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* The results obtained on sisal workers have not yet been completely analyzed, detailed data are therefore not reported.

As seen from Figure 1 hemp and flax dust caused approximately equal prevalence of byssinosis (42 and 46 percent respectively), cotton caused considerably lower prevalence (24 percent) while no byssinosis was caused by either jute or sisal dust. Highest prevalence of chronic respiratory symptoms was recorded in hemp workers (36 percent), followed by flax (31 percent) and cotton workers (26 percent) while prevalence in sisal (14 percent) and jute workers (11 percent) was lower. The highest relative mean acute Monday reduction of $FEV_{1.0}$ was measured in hemp workers (19 percent), followed by flax (11 percent), cotton (8 percent), sisal (7 percent) and jute workers (5 percent). As the number of workers in each group was small it would be premature to attempt drawing definite conclusions as to the relative activity of the five types of vegetable dust examined. Investigations in the forthcoming stages of the project by increasing the number of subjects studied, will probably more clarify this question.

The experiments made with the inhalation of Alupent in hemp workers after shift have shown that the acute effects of vegetable dust exposure are at least partly reversible. By applying Alupent before the shift we have succeeded in significantly diminishing the reduction of ventilatory capacities during the shift, although not preventing it completely. The subjects interviewed as to their subjective feelings during the shift after Alupent inhalation claimed they felt better. We are planning to repeat the experiments with the greater doses of Alupent to be applied before the shift in order to find out if this could enhance the preventive effect of the bronchodilator.

It is difficult to interprete the byssinosis prevalence found in the three cotton mills. The three mills did not differ in the mean concentration of the respirable airborne dust, yet they differed very markedly in the prevalence of byssinosis. In Mill A the mean total dust concentration was found almost four times as high as the concentration in Mill B, yet the prevalence of byssinosis in the former was found to be nil and 20.8 percent in the latter. The mean duration of exposure to cotton dust was longer in Mill B which, to some extent, might have accounted for the higher byssinosis prevalence. In Mill C, however, with practically the same respirable dust concentration as in Mill A and with the almost four times lower total dust concentration, the prevalence of byssinosis was found to be 28.3 percent, although the mean duration of exposure of the workers examined was only 5 years. This unexpected relationship between airborne dust concentrations and the byssinosis prevalence (and to some extent the magnitude of acute reductions of ventilatory capacity over shift) raises doubts as to whether either the total or the respirable (as currently defined) dust concentration could be used as an index of the dust hazard level. The definition of "respirable particle fraction" is based on the assumption of alveolar particle deposition which is justified for pneumoconiosis-producing particles but not for particles causing changes in bronchi or broncioles. The size-selective characteristics of the first stage of two-stage dust samplers for sampling the latter kind of dust should differ from those used for pneumoconiosis-producing dust sampling.

In addition, it is obvious that the biologic activity of dust should also be taken into account when dealing with the pharmacodynamic dusts. The biologic activities of cotton dust in the three cotton mills studied are likely to have differed significantly in their respective biologic activity. The results of our preliminary testing appear to support this assumption.

The assessment of vegetable dust hazard will most likely have to be done on the basis of specific respirable airborne dust determination considering, at the same time, the biologic activity of dust.

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Table 1

Byssinosis and Respiratory Symptoms in Hemp Workers

		Carders	Spinners	Total
N		42	60	102
Ave. Age (yrs.)		33	35	34
Ave. Exposure (yrs.)		10	10	10
Mean Dust Concentrations (mg/m^3)	Total	26.93	6.24	
	Respirable*	0.87	2.66	
Byssinosis (percent)		49	32	39
Persistent Cough (percent)**		67	43	53
Persistent Phlegm (percent)		55	37	44
Dyspnea 2 and 3 (percent)		37	27	31

* Respirable - fine dust collected on filter after elutriation.

** The only significant ($p < 0.05$) difference in prevalence of respiratory symptoms between carders and spinners.

Table 2

Prevalence of Respiratory Symptoms and Mean Values of Ventilatory Function Tests in Hemp Workers and Control Subjects on Monday Before Work

	With Byssinosis	Control	p	Without Byssinosis	Control	p
N	40	33		62	45	
Age (yrs)*	32 18-51	30 18-50		35 18-49	34 18-51	
Height (cm)*	158 147-173	159 149-172		158 148-174	158 150-170	
Persistent Cough (%)	78	15	< 0.01	37	9	< 0.01
Persistent Phlegm (%)	65	18	< 0.01	31	13	< 0.05
Chronic Bronchitis (%)	56	12	< 0.01	30	11	< 0.05
Dyspnea Grade 2 and 3 (%)	38	0	< 0.01	26	4	< 0.01
$FEV_{1.0}$ (ml)	2753	3295	< 0.01	2755	3215	< 0.01
FVC (ml)	3504	3742	NS	3395	3584	< 0.01
$FEV_{1.0}$/FVC (%)	78.6	88.1	< 0.01	81.2	87.3	< 0.01

* Mean and range.
NS - not significant ($p > 0.05$).

Table 3

Ventilatory Function Tests in Exposed and Control Workers

Group	N	Test	Day	Mean Lung Function Data (ml) Before Shift	After Shift	Change	p
Hemp Workers with Byssinosis	40	$FEV_{1.0}$	Monday	2753	2177	-576	< 0.01
						< 0.01	
			Thursday	2737	2621	-116	< 0.01
		FVC	Monday	2504	3355	-149	< 0.01
						< 0.01	
			Thursday	3450	3452	+2	NS
Hemp Workers Without Byssinosis	62	$FEV_{1.0}$	Monday	2755	2451	-304	< 0.01
						< 0.01	
			Thursday	2690	2578	-112	< 0.01
		FVC	Monday	3395	3244	-151	< 0.01
						< 0.01	
			Thursday	3360	3309	-51	< 0.01
Controls	78	$FEV_{1.0}$	Monday	3247	3249	+2	NS
			Thursday	3255	3258	+3	NS
		FVC	Monday	3707	3700	-7	NS
			Thursday	3707	3705	-2	NS

NS - not significant ($p > 0.05$).

Table 4

Effect of Bronchodilator Application After Shift

Group	N	Test	Before Shift 1	After Shift 2	t_{1-2}	After Broncho-dilator 3	t_{1-3}
With Byssi-nosis	20	Mean $FEV_{1.0}$	2825	2007	10.7*	2580	3.7*
		Mean FVC	3600	3379	5.0*	3584	1.6⁻
No Byssi-nosis	24	Mean $FEV_{1.0}$	2850	2135	7.8*	2780	1.3⁻
		Mean FVC	3610	3423	4.4*	3590	0.6⁻

* Statistically significant difference ($p < 0.01$).

⁻ Not significant ($p > 0.05$).

Table 5

Effect of Bronchodilator Application Before Shift

Group	N	Test	Before Shift: Before Broncho-dilator 1	Before Shift: After Broncho-dilator 2	After Shift 3	t_{1-3}
With Byssi-nosis	20	Mean $FEV_{1.0}$	2825	2825	2410	4.9*
		Mean FVC	3600	3620	3548	2.7**
No Byssi-nosis	24	Mean FEV	2850	2850	2576	6.3*
		Mean FVC	3610	3622	3560	2.1**

* Statistically significant ($p < 0.01$).

** Statistically significant ($p < 0.05$).

Table 6

Dust Concentrations in the Cotton Mill A

Concentrations (mg/m^3)	Total Dust (mg/m^3)	Respirable Dust (mg/m^3)
Mean	15.23	0.43
Maximum	82.35	1.32
Minimum	0.71	0.03

Table 7

Prevalence of Respiratory Symptoms Among Male and Female Cotton Workers in Mill A

Group	N	Chronic Bronchitis		Dyspnea Grade 3 and 4	
		N	%	N	%
Men	18	4	22.2	1	5.6
Women	70	10	14.3	13	18.6
Total	88	14	15.9	14	15.9

No case of byssinosis was registered.

Table 8

Mean $FEV_{1.0}$ and FVC Changes Over Shift in Female Cotton Workers in Mill A

Group	N	Test	Day	Mean Values (ml)			
				Before Work	After Work	Reduction	P
Women	70	$FEV_{1.0}$	Monday	2772	2635	-137	<0.01
			Thursday	2787	2746	-41	<0.05
		FVC	Monday	3552	3519	-133	<0.01
			Thursday	3529	3492	-37	NS

Table 9

Dust Concentrations in the Cotton Mill B

Concentrations (mg/m^3)	Total Dust (mg/m^3)	Respirable Dust (mg/m^3)
Mean	4.05	0.48
Maximum	9.11	0.60
Minimum	1.06	0.24

Table 10

Prevalence of Chronic Bronchitis and Dyspnea in Mill B

Group	N	Chronic Bronchitis N	Chronic Bronchitis %	Dyspnea Grade 3 and 4 N	Dyspnea Grade 3 and 4 %
With byssinosis	11	6	54.5	2	18.1
Without byssinosis	42	11	26.1	1	2.4
Total	53	17	32.1	3	5.7

Prevalence of byssinosis 20.8%.

Table 11

Ventilatory Function Changes in Cotton Workers in Mill B

Group	N	Test	Day	Mean Values (ml) Before Work 1	After Work 2	Reduction	P 1-2
Exposed Workers	53	$FEV_{1.0}$	Monday	2796	2487	-309	< 0.01
			Thursday	2786	2710	-76	< 0.01
		FVC	Monday	3546	3380	-166	< 0.01
			Thursday	3501	3432	-69	< 0.01

Table 12

Mean Reductions in Lung Function Values on Monday and Thursday in Cotton Mill B

Group	N	Monday 1	Thursday 2	p 1-2	Monday 1	Thursday 2	p 1-2
With byssinosis	11	-515	-77	<0.01	-189	-73	<0.01
Without byssinosis	42	-255	-75	<0.01	-160	-66	<0.01
With byssinosis without byssinosis		NS	NS		NS	NS	

NS - not significant ($p > 0.05$).

Table 13

Dust Concentrations in the Cotton Mill C

Concentrations (mg/m^3)	Total Dust (mg/m^3)	Respirable Dust (mg/m^3)
Mean	4.18	0.64
Maximum	12.73	1.09
Minimum	0.63	0.10

Table 14

Prevalence of Respiratory Symptoms in Mill C

Group	N	Chronic Bronchitis		Dyspnea Grade 3 and 4	
		N	%	N	%
With Byssinosis	17	5	29.4	2	17.6
Without Byssinosis	43	9	20.9	4	9.3

Prevalence of Byssinosis 28.3%

Table 15

Ventilatory Function Test in Female Cotton Workers in Mill C on Monday and Thursday (N = 60)

Days	Mean Changes					
	$FEV_{1.0}$ ml	P	FVC ml	P	PEF (1/min)	P
Monday	-138	<0.01	-108	<0.01	-23	<0.01
	0.05		NS		0.05	
Thursday	-92	<0.01	-78	<0.01	-13	<0.01

NS - not significant ($p > 0.05$).

Table 16

Ventilatory Function Tests in Female Cotton Workers
Over the Shift on Monday in Mill C

Group	N	Mean Reductions					
		FVC		$FEV_{1.0}$		PEF	
		ml	p	ml	p	1/min	p
With Byssinosis	17	-134	<0.01	-174	<0.01	-27	<0.01
		NS		NS		NS	
Without Byssinosis	43	-98	<0.01	-123	<0.01	-22	<0.01
Total	60	-108	<0.01	-138	<0.01	-23	<0.01

Table 17

Dust Concentrations in Jute Mill

Concentrations	Total Dust (mg/m^3)	Respirable Dust (mg/m^3)
Mean	3.22	0.73
Maximum	7.62	1.09
Minimum	0.68	0.11

Table 18

Prevalence of Chronic Bronchitis in Jute Mill

N	Chronic Bronchitis N	Chronic Bronchitis %	Dyspnea Grade 3 and 4 N	Dyspnea Grade 3 and 4 %
92	13	14.2	1	1.1

No case of byssinosis registered.

Table 19

Ventilatory Function Test in Jute Workers
on Monday and Thursday (N = 92)

Days	Mean Changes					
	$FEV_{1.0}$ (1)	P	FVC (1)	P	PEF (1/min)	P
Monday	-0.12 <0.01	<0.01	-0.06 <0.05	<0.01	-15 <0.01	<0.01
Thursday	-0.07	<0.01	-0.03	<0.01	-11	<0.01

Table 20

Mean Total Dust Concentration and Prevalence of Respiratory Symptoms in Flax Workers

N	Ave. Age (yrs)	Ave. Exposure (yrs)	Mean Dust Concentration (mg/m^3)	Byssinosis %	Chronic Bronchitis %
30	32	10	6.368	40	47

Table 21

The Prevalence of Chronic Bronchitis in Byssinotic and Non-Byssinotic Flax Workers

Group	N	Ave. Age (yrs)	Ave. Exposure (yrs)	Chronic Bronchitis %
With Byssinosis	12	34	12	75
				< 0.01
Without Byssinosis	18	31	9	28

Table 22

Mean Changes of Ventilatory Capacity During Shift in Flax Workers

Group	No	Day	FVC (ml)				$FEV_{1.0}$ (ml)			
			Before Shift	After Shift	Change	t	Before Shift	After Shift	Change	t
Exposed	30	Mon.	3623	3417	-206	5.7*	2875	2454	-421	7.1*
		Thurs.	3555	3423	-132	4.6*	2771	2589	-182	6.6*
Control	60	Mon.	3705	3704	-1	0.2**	3254	3258	+4	0.9**
		Thurs.	3704	3705	+1	0.3**	3262	3260	-2	0.1**

* Statistically significant change ($p < 0.01$).
** Not significant ($p > 0.05$).

Table 23

Mean Changes in $FEV_{1.0}$ and FVC Over Shift on Monday and Thursday in Flax Workers

Group	N	$FEV_{1.0}$ (ml) Monday	Thursday	P	FVC (ml) Monday	Thursday	P
With Byssi-nosis	12	-468	-245	< 0.05	-245	-141	NS
		NS	NS		NS	NS	
Without Byssi-nosis	18	-391	-140	< 0.01	-181	-126	NS

NS - not significant ($p > 0.05$).

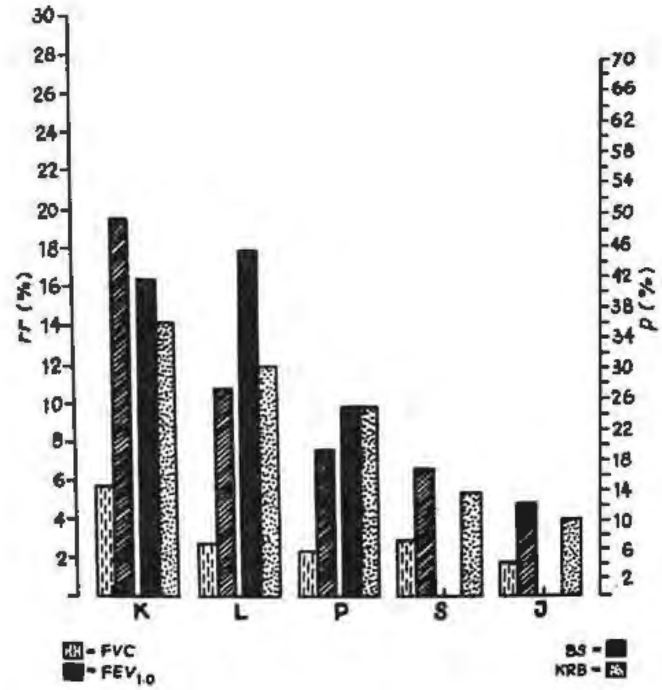

Figure 1. Comparison of the results obtained in workers exposed to five different types of vegetable dust.

FVC : Forced Vital Capacity
$FEV_{1.0}$: Forced Expiratory Volume in the first second
BS : Byssinosis
KRB : Chronic Respiratory Symptoms
p (%) : Prevalence in percentage
rr (%) : Relative reduction in percentage

DISCUSSION AFTER DR. VALIC'S PAPER:

Dr. Saric:

Will you, for comparative reasons, say a few words about the definition of chronic bronchitis you used in these tables you showed to us, and also the definition of byssinosis.

Dr. Valić:

The definition of chronic bronchitis that we used is the well-known definition of Fletcher of the British Medical Research Council, that we take it as a condition characterized by a productive cough at least three months in the year during at least two consecutive years provided other pulmonary diseases have been excluded. This is a well-recognized definition of chronic bronchitis. The definition of byssinosis is a little bit more difficult because, in fact, there is no definitely accepted definition of byssinosis. But what we take as byssinosis is probably what the majority of the workers in byssinosis in the world take now and that is a pulmonary disease characterized by a chest tightness on first working day and subsequent working days after a short break in exposure of a day or more and accompanied by a sharp reduction of ventilatory capacity. But the second part of the definition is put in brackets because many people do not take that into consideration. As a matter of fact I must say that even we did not definitely always consider the second part. So the significant acute change ventilatory capacity.

Dr. Potkonjak:

I apologize, perhaps I missed hearing you, but I really didn't hear whether your subjects were smokers or non-smokers or both? Because I think some correlation between byssinosis and chronic bronchitis, it seems to me, is possibly only in non-smokers.

Dr. Valić:

Thank you Dr. Potkonjak to have put it so nicely that you may be mishearing me because I really didn't say it. All our subjects were non-smokers, and I fully agree with you that the correlation between byssinosis prevalence and chronic bronchitis probably in the pure form of correlation is to be expected only for non-smokers.

Dr. Cralley:

I agree with Dr. Valić on the definition of the term "respirability." It may be different depending on the type of dust and the area of the respiratory system affected. The type of sampling instrument will have to take these facts into consideration. As I recalled the concentrations of a dust from the flax, hemp, and cotton were all at the same general levels. I don't recall any similar data you have on the sisal or jute. Are different industrial operations concerned with these than those of the flax, hemp, and cotton as far as production is concerned?

Dr. Valić:

The technology that we found in the plants where we studied jute and sisal workers is different than the technology of flax, hemp, and cotton workers and especially in the initial stages of the process. As a matter of fact, there are not initial stages of the process in the jute and sisal workers.

Dr. Szymczykiewicz:

I should like to speak again about micro-organism problems. Are you sure Dr. Valić that these constrictor compounds, which you obtained from the cotton dust, are really of cotton origin, because we extracted the bacteria living in the cotton dust and we know that these bacteria produce endotoxins which have had the same constrictor effect on muscles like these obtained in your investigation. For my opinion, it is impossible to separate bacteria from the dust. I suppose that effect in your investigations may be also produced by the endotoxin extracted from bacteria living on the surface of organic dust.

Dr. Valić:

I cannot answer you from the basis of our results because we do not have our results. When I made the remark in respect to the bacterial pollution I did not speak about cotton then, because our experience in this respect is not connected to cotton. It is connected to completely different sort of organic dusts. That is number one. Secondly, speaking of endotoxin, now we have not seen the experiments in Italy and had the chance of discussing the endotoxin theory proposed for pathogenesis of byssinosis. I think that the main weak point of the endotoxin in vegetable dust is that it cannot be so high as to produce such very strong acute effects as we found in here.

Dr. Szymczykiewicz:

The bacteria, living in the cotton dust are simply saprophytes living mainly on the surface of the earth and in the water. I am not sure that these bacteria don't exist in other dust, for instance, jute, flax, and so on. I didn't investigate it in the flax and jute, but it seems to me that these same bacteria are living in all organic dusts.

Dr. Valić:

I really cannot say anything about cotton in this respect. I just don't know. You may be right. I think that the results published so far do indicate that the bacterial action would not cause such strong acute effects as that found in this cotton dust. So it is probably a pharmacological action, rather than the bacteriological action. Our other experiments speak against these questions of bacteria.

Dr. Potkonjak:

As I remember, you showed that decrease of FEV values is parallel with the increase of the years of work. Don't you consider that some other factors could come into the play. For example: the role of the age, the role of the emphysema developed. Therefore, I would like to ask you: it is now emphasized that FEV is a non-physiological test which can give us false results. Especially in a subject of higher age and it is suggested that only measurement of the airway resistance can be really useful.

Dr. Valić:

First of all as to your question whether age could be responsible for the effect, I think we excluded this effect. We carried out multiple regression analyses and made allowance for the age effect. We did it in another way besides this mathematical correlation by having control groups. Matching the exposed group and control group in age we did not find the same effect of the drop of FEV. That is number one. Now your second remark of course whether we should consider FEV as a satisfactory basis for testing some lung function. That is another point. As you know the majority of researchers use FEV tests as the simpliest test for epidemiological studies.

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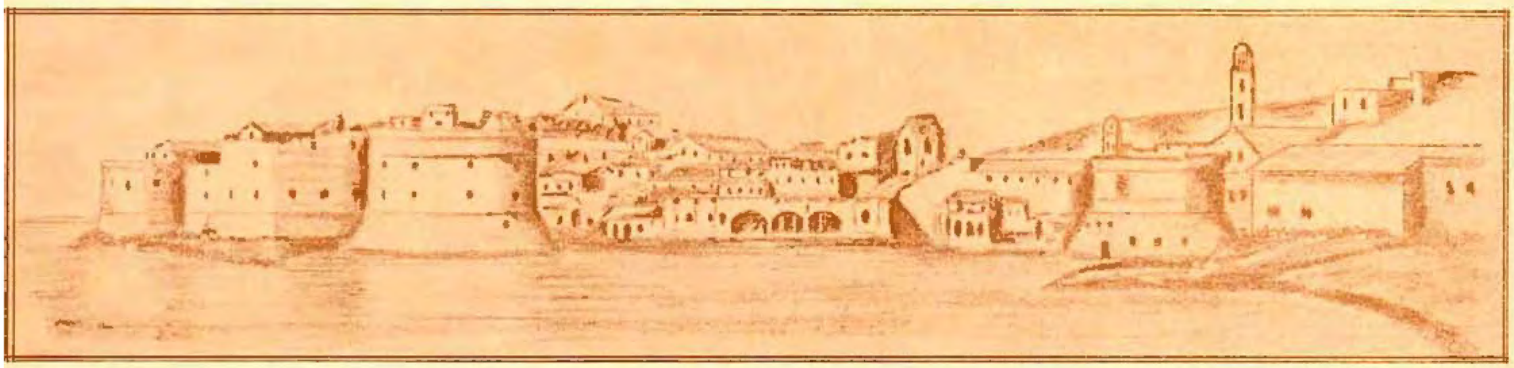

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