PERSONAL DUST SAMPLING WITH THE CIP-10 FOR A BETTER MEDICAL MANAGEMENT OF THE PNEUMOCONIOSIS RISK IN COAL MINES

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INTRODUCTION

In French coal mines, static sampling is used for regulatory measurements of ambient dust concentrations in workings. In 1983 however, the personal dust sampler CIP-10 became commercially available. This air sampling instrument was designed by CERCHAR ("Centre d'Etudes et Recherches de Charbonnages de France") to measure individual exposures to respirable dust in mining environments.

The CIP-10 is a small (18 x 7 x 2.5 cm) and light (300 g) instrument, conveniently worn by the miners. It can be lodged into a chest pocket or into a chest strap. Wearing the CIP-10 is generally well accepted by the workers. The sampler is operating at a flow rate of 10 l/min and collects the respirable fraction of the dust within a rotary foam. Dust can be ashed or extracted from the foam for laboratory analyses, such as free silica determination. The CIP-10 has enough autonomy to cover a full 8-hour shift. More technical information on the CIP-10 is available elsewhere (Courbon et al, 1988).

Personal sampling greatly modified our existing views on dust exposure in coal mines. Results of a large scale monitoring study of personal exposures to respirable dust in French coal mines have just been reported (Bruyet et al, 1988). Several more specific surveys were carried-out at the request of the occupational physicians from collieries in Lorraine. They provided other useful informations, examples of which are given in this report.

USEFULNESS OF PERSONAL DUST SAMPLING

Documenting Specific Exposures

In French mines, some goafs must be filled-up, especially in the case of flat working, when heating, water irruption or mining damages are feared. When hydraulic stowing is not possible, pneumatic stowing is sometimes used to fill-up the goafs with shales. The shales are collected in the washing plants, sent back underground with successive tubings, belt-conveyed to the face and sprayed out pneumatically from a stowing machine located in the top road. Since it was often found in the career of pneumoconiotics, this technique was suspected to carry a substantial pneumoconiosis risk.

In February 1984, a survey was carried out in a particular working at Wendel mine to measure personal exposures associated with the pneumatic stowing technique. For a period of 10 days, all workers engaged in the operation and two technicians were equipped with a CIP-10. Measurement results are reported in Tables I and II. Concentrations of respirable dust were in the range 11.2–91.5 mg/m^3. Such

Table I
Personal Dust Sampling with the CIP 10
Pneumatic Stowing Technique
Wendel Pit, February 1984

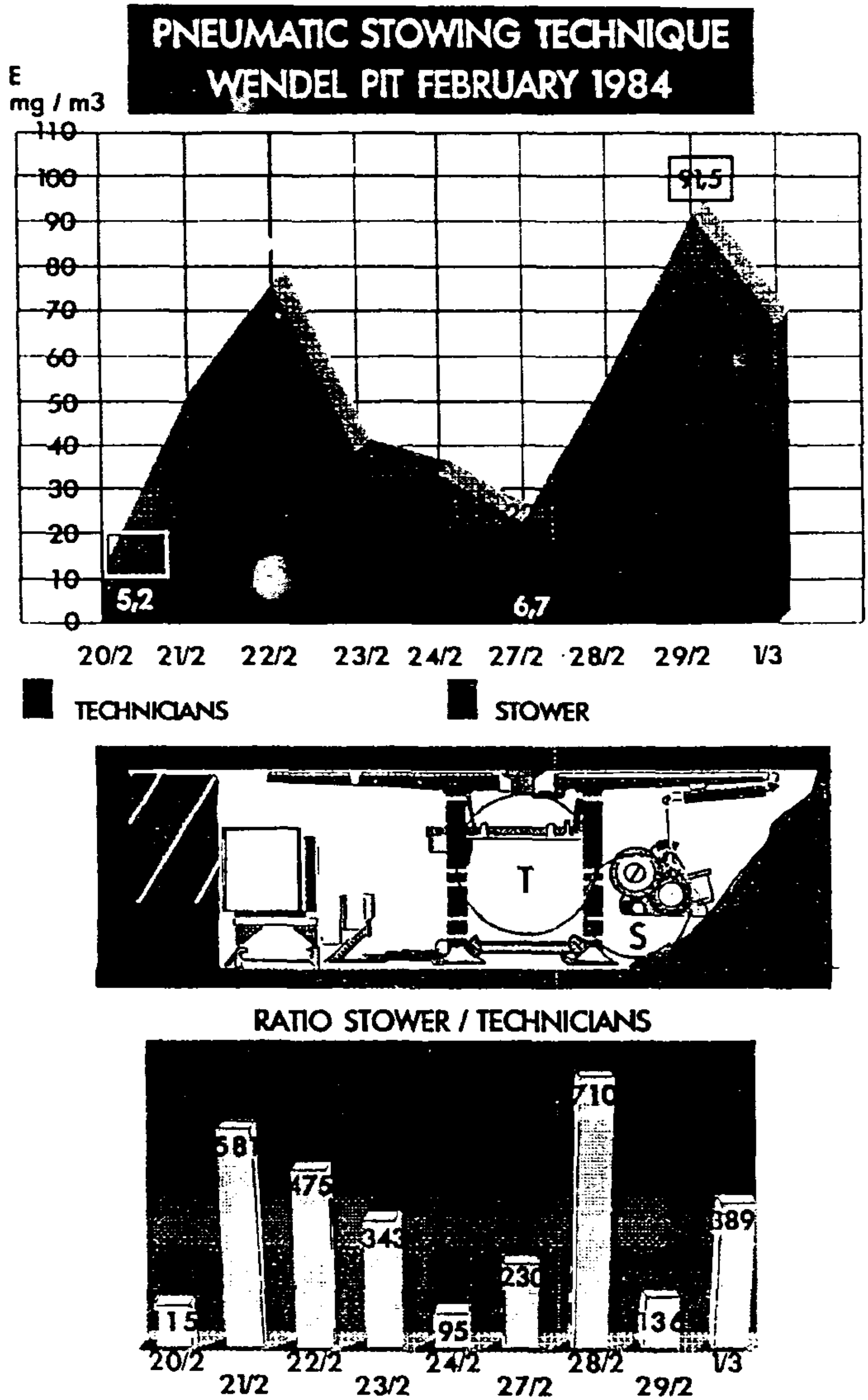
		20/2	21/2	22/2	23/2	24/2	27/2	28/2	29/2	1/3
Pneumatic	T n°138 T n°139	3,70 6,70	8,00 7,40	15,30 11,70	9,00 8,80	20,10 14,10	6,40 7,10	7,20 6,70	40,00 37,50	12,50 15,40
Stowing	Mean	5,20	7,70	13,50	8,90	17,10	6,70	6,90	38,70	14,00
Technique	S n°140	11,20	52,50	77,70	39,50	33,50	22,10	55,90	91,50	68,50
	Ratio S/T	115%	581%	475%	343%	95%	230%	710%	136%	389%

RESULTS OF RESPIRABLE DUST IN MG/M3

T = Technicians

S = Stower

Table II
Personal Dust Sampling with the CIP 10



high figures are reported with caution, since a saturation effect was observed with the CIP-10 at very high concentrations. The stower was the most exposed. By-standers could be 8 times less exposed. Pneumatic stowing was also affecting the exposures of people at the face. The pneumatic stowing technique is not used any more in mines from Lorraine since the end of 1986.

Other surveys with the CIP-10 were able to document unsuspected exposures, such as those experienced by the electromechanics underground. These people maintain the energy sources and the mining equipment. They generally stand out of the face, except in case of failure of the machinery. Because not directly involved in coal extraction, they are not considered as "exposed" personnel according to regulations.

In the period June 10th–June 19th 1987, all electromechanics from a working wore a CIP-10. Their activities were observed and recorded. Tables III and IV present measurements of personal exposures and of ambient concentrations 15 m above the working in the top road on the air return. Values for personal exposures were linearly related to the time spent at the face or in the top road. The highest exposure reached the standard level for regulatory ambient concentration.

In another survey, the exposures of 16 workers involved into heading operations in the seams were measured during 5 days. Three exposure zones were defined: (1) the shearing area, (2) between the shearing area and the deduster and (3) from the back of the deduster up to the entrance of the headings. A total of 55 measurements were done. Among those, 16 were in excess of 2 mg/m^3. Interestingly enough, most of the excessive exposures occurred in zone 3, a day when the shearer did not operate. (Tables V and VI).

Assessing the Validity of Job Re-allocation

In French collieries, medical management of the pneumoconiosis risk is mainly based on job re-allocation. Diagnosed cases are moved to workings known to be less dusty. The dustiness of each working is deducted from the results of regulatory measurements done by static sampling. A survey was carried out with the CIP-10 in order to check if this way of re-allocating jobs was effectively ensuring less severe personal exposure for these diagnosed cases.

In Summer 1987, 40 active miners with a chest X-ray scored 0/1 and 30 active miners compensated for pneumoconiosis were selected. Personal exposures of workers in the two groups were assessed by a total of 476 measurements with the CIP-10. Results are reported in Tables VII and VIII. In average, exposures were less for pneumoconiotics (0.63–0.67 mg/m^3) than for other re-allocated but uncompensated workers (0.89 mg/m^3). Some personal exposures in excess of 2 mg/m^3 were, however, detected (Mahieu et al, 1988). These cases were immediately corrected.

Table III

Personal Dust Sampling with the CIP 10

DATE		Static Measures	EXPOSURE SITES DURING THE SHIFT									
			Entry & Bottom road		Bottom road		Bottom road Coal face & Top road		Coal face & Top road		Top road	
Day	Shift	mg/m3	mg/m3	%	mg/m3	%	mg/m3	%	mg/m3	%	mg/m3	%
10/6	1 2	3,98 5,15					1,72	4,32	3,30 3,72 2,49 2,53	82,90 93,40 48,30 49,10	(0,50)	
11/6	1 2	4,17 1,83			1,94 1,34 1,58 1,32	46,50 73,20 86,30 72,10	3,80	91,10			4,27	102,30
12/6	1 2	4,17 4,09 4,99			1,84	44,10			3,00	73,30	4,28 3,85 5,05	102,60 92,30 101,20
15/6	1 2	(0,33) 4,21	1,66				2,97 2,79	70,50 66,20			3,87 3,96 4,04	95,90
16/6	1 2	5,20 5,79			2,97	57,10	1,86 3,92	67,70			5,89 5,89	113,20 113,20
17/6	1 2	5,99			3,07 1,83	51,20	5,24				3,72 6,14	62,10 120,50
18/6	1 2	5,23 5,81			1,70	32,50	4,04 3,54 2,99	77,20 67,60 51,40	4,25	73,50		
19/6	1 2	4,26			1,35		1,83 2,85 2,50 1,24	42,90 66,90			5,31	124,60
Values Means SEM		14,00 4,63 1,03	1,00 1,66 ,00		10,00 1,89 ,60	8,00 57,88 16,78	14,00 2,95 1,05	10,00 60,58 22,45	6,00 3,22 ,63	6,00 70,08 16,56	12,00 4,69 ,87	10,00 102,79 16,80

PERSONAL DUST SAMPLING WITH THE CIP 10

ELECTROMECHANICS

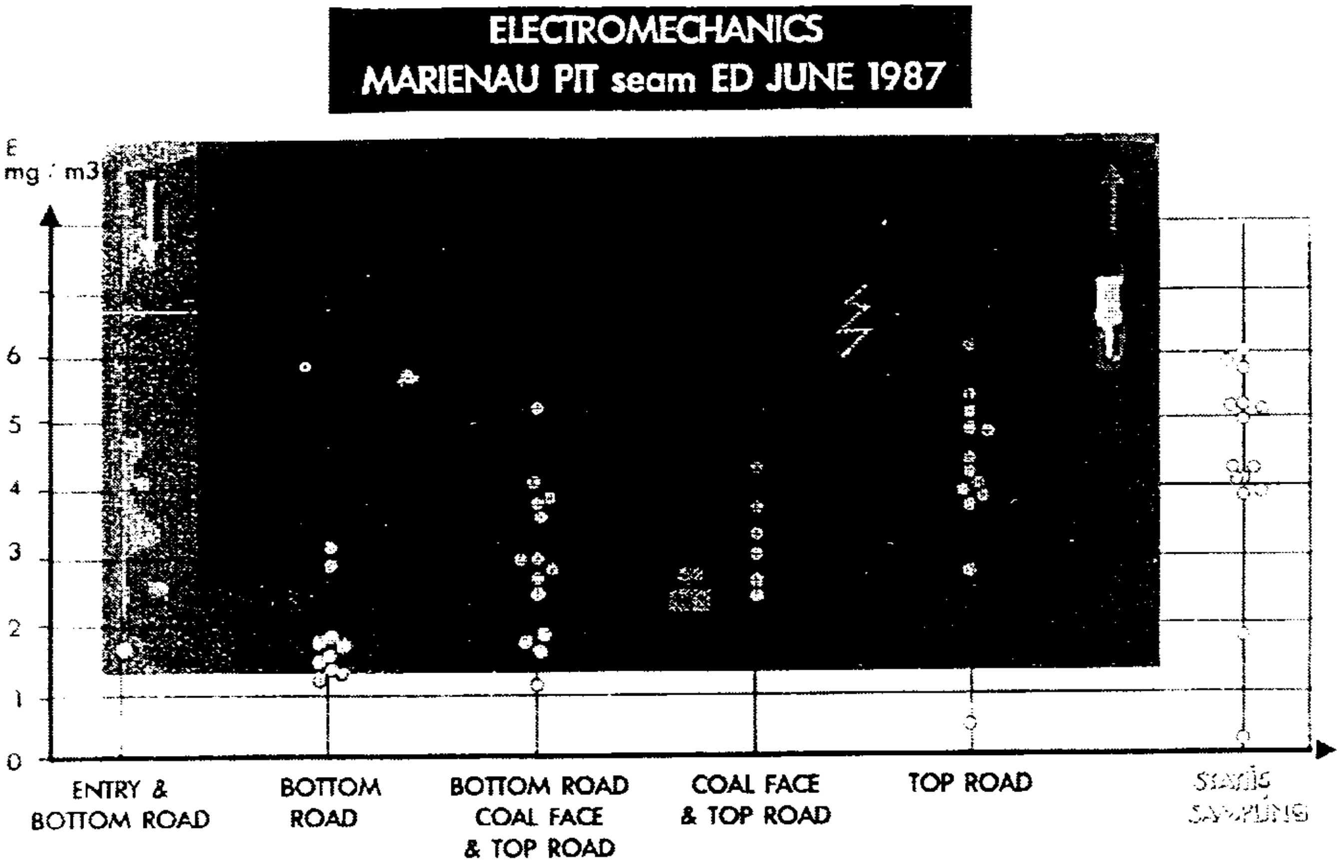
MARIENAU PIT Seam ED
JUNE 1987

Results of respirable dust in mg/m3

Results of individual measures & in the ratio of ambient regulatory measurements (15 m above the working in the top road on the air return)

(*) doubtful values

Table IV
Personal Dust Sampling with the CIP 10



DISCUSSION

According to the governmental directives of December 1975, in the French coal mines the concentration of respirable dust is regularly controlled and measured by static ambient sampling in well-defined locations. The respirable dust is collected using the CPM3 air sampling instrument (Fabries et al., 1987). Workings are ranked according to their dustiness. Standard levels are in terms of gravimetric concentration of respirable dust (as collected by the CPM3) in the ambient air. The observed differences in the pneumoconiotic risk among coal fields (Amoudru, 1987) have been taken into account to define standard levels which are specific to each coal field. In Lorraine, the standard level is at 4.5 mg/m^3 below 7% free silica, and gradually decreases above 7%. All the workings are regularly classified according to this level.

Also the regulations impose for any worker exposed an annual medical examination and a chest X-ray. At the term of that examination, every year the occupational physician defines for each worker the types of workings in which he can be employed, essentially in function of the data of the chest radiography. So the sound subject (Aptitude 1) will be able to work everywhere (workings ranked O, A, B, C, D, E) and the serious pneumoconiotics (aptitude 5) will only be authorized to work in non dusty working places (rank O); in general they are re-allocated in surface jobs.

We know now that there is a heterogeneity of exposures within the workings. This one could have been in the past at the origin of some cases of early and/or severe pneumoconiosis. Reallocation must also take into account this heterogeneity. Internal procedures are now in place for a better protection of active miners with slight X-ray changes (score 0/1): their exposures are followed to limit under 5 g the annual cumulative inhaled dose according to their work loads.

Another advantage of personal sampling in coal mines is the ability to detect unsuspected high exposures. The surveys among electromechanics and among workers engaged in heading operations beautifully illustrated this point.

Those different studies carried out with the CIP-10 on the indications of the occupational physician have brought useful contributions to the improvement of the technical and medical prevention of pneumoconiosis in our coal mines. The CIP-10 has been found to be a reliable instrument. Personal sampling is considered useful to identify needs for appropriate control measures and to follow cases at risk.

REFERENCES

1. Amoudru, C. (1987). Les pneumoconioses: dimension actuelle des problèmes Colloque *INSERM*, 155:3-40.
2. Bruyet, B., P. Courbon, and P. Sébastien, (1988). *Personal exposures to respirable dust in French coal mines*. Presented at the international symposium on pneumoconiosis, Shen Yang, China, May 30–June 2, 1988.
3. Courbon, P., R. Wrobel, and J.F. Fabries, (1988). A new individual dust sampler: the CIP-10 *Ann. Occup. Hyg.* 32:1, 129-143.
4. Fabries, J.F., R. Wrobel, and P. Courbon (1987). A compact high-flowrate respirable dust sampler: the CPM3 Ann. *Occup. Hyg.* 31:2, 195-209.
5. Mahieu, B., E. de Surgy, and M. Zitter, (1988). Surveillance des agents suspects de Pneumoconiose par capteur individuel de poussières dans les mines de charbon. Presented at the 20th Journées Nationales de Médecine du Travail Toulouse, France, May 18-21, 1988.

Table V

Personal Dust Sampling with the CIP 10

Heading Workings

Marienau Pit SDS June 1988

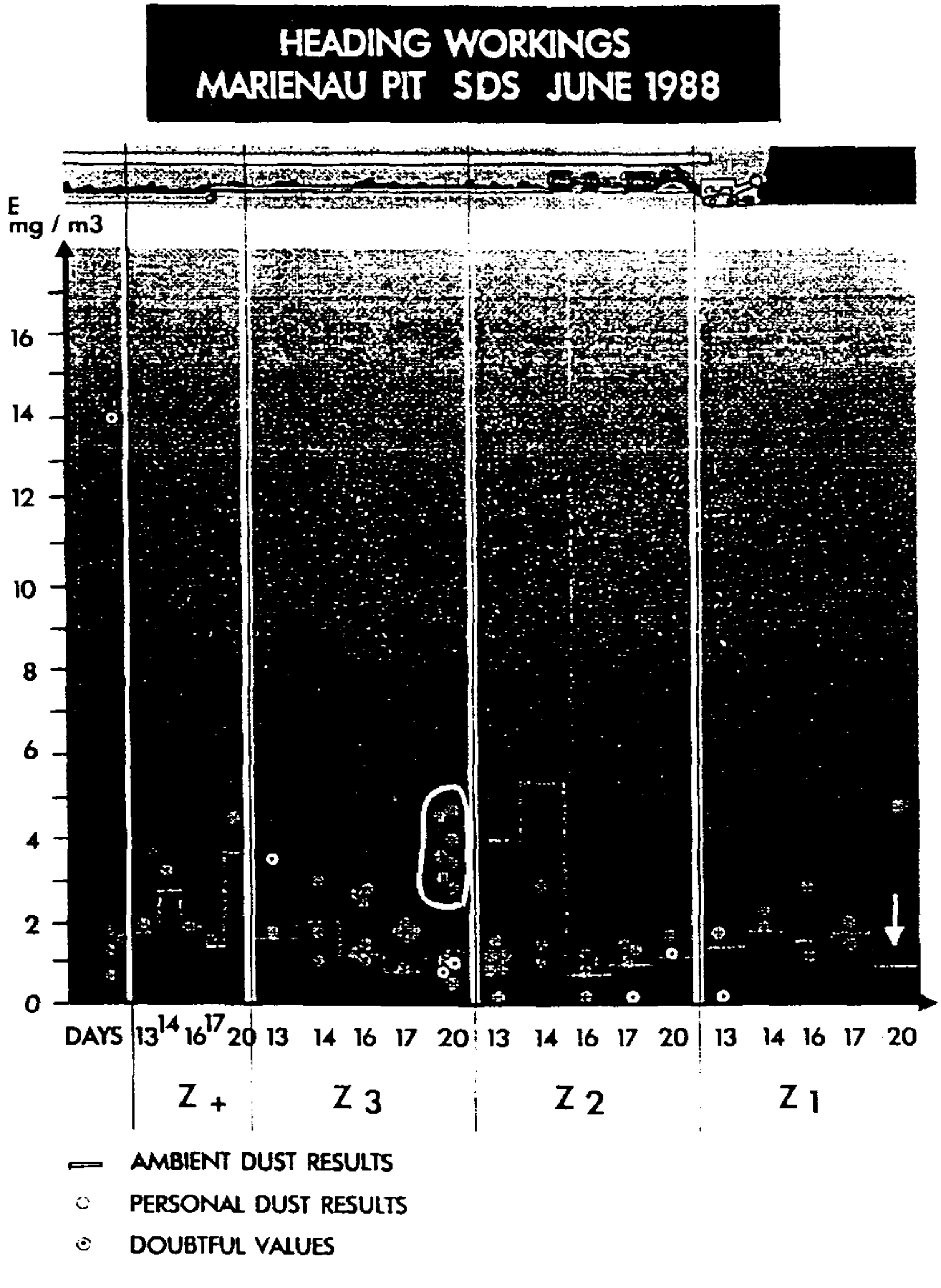
EMPLOYMENT	13/6		14/6		16/6		17/6		20/6	
Overman	iTi.	1,63	iTi.	,59	iTi.	(13,0)	iTi.	1,67	Z3	1,12
Haulager	Z3	(3,10)							Z3	(,92)
Haulager							Z3	1,66	Z3	2,51
"Débloqueur"	Z+	1,88	Z+	2,99	Z+	1,83	Z+	1,61	Z+	3,64
Annexes					Z3	2,68	Z2	1,39	Z3	,50
Piper	Z2	1,40	Z3	2,85	Z3	1,40	Z3	1,66	Z2	(1,15)
Piper	Z2	1,14	Z3	1,27	Z3	2,64	Z3	1,61		
"Resserrage bride"					Z3	2,42				
Divers			Z3	1,74	Z3	1,04	Z3	1,00	Z3	2,81
Divers	Z3	1,67			Z3	1,18	Z3	1,85	Z3	1,04
Hewer	Z2	(,08)	Z2	1,48	Z2	1,13	Z2	1,41	Z2	1,56
Hewer	Z2	1,04	Z1	1,96	Z2	,11	Z1	1,41	Z3	4,26
Hewer	Z2	1,06	Z2	2,57	Z2	1,21	Z2	1,06	Z3	4,35
Hewer	Z2	,93	Z2	1,01	Z2	,80	Z2	(,01)	Z3	3,14
Cutterman	Z1	1,58			Z1	2,52			Z3	3,69
Cutterman	Z1	(,18)	Z1	1,75	Z1	1,34	Z1	1,85	Z3	3,10

(*) doubtful values

Results of respirable dust in mg/m3

Activity and localisation of workers during the shift

Table VI
Personal Dust Sampling with the CIP 10



REPARTITION ACCORDING TO THE ZONES AND TO THE DAYS

Table VII
Personal Dust Sampling with the CIP 10

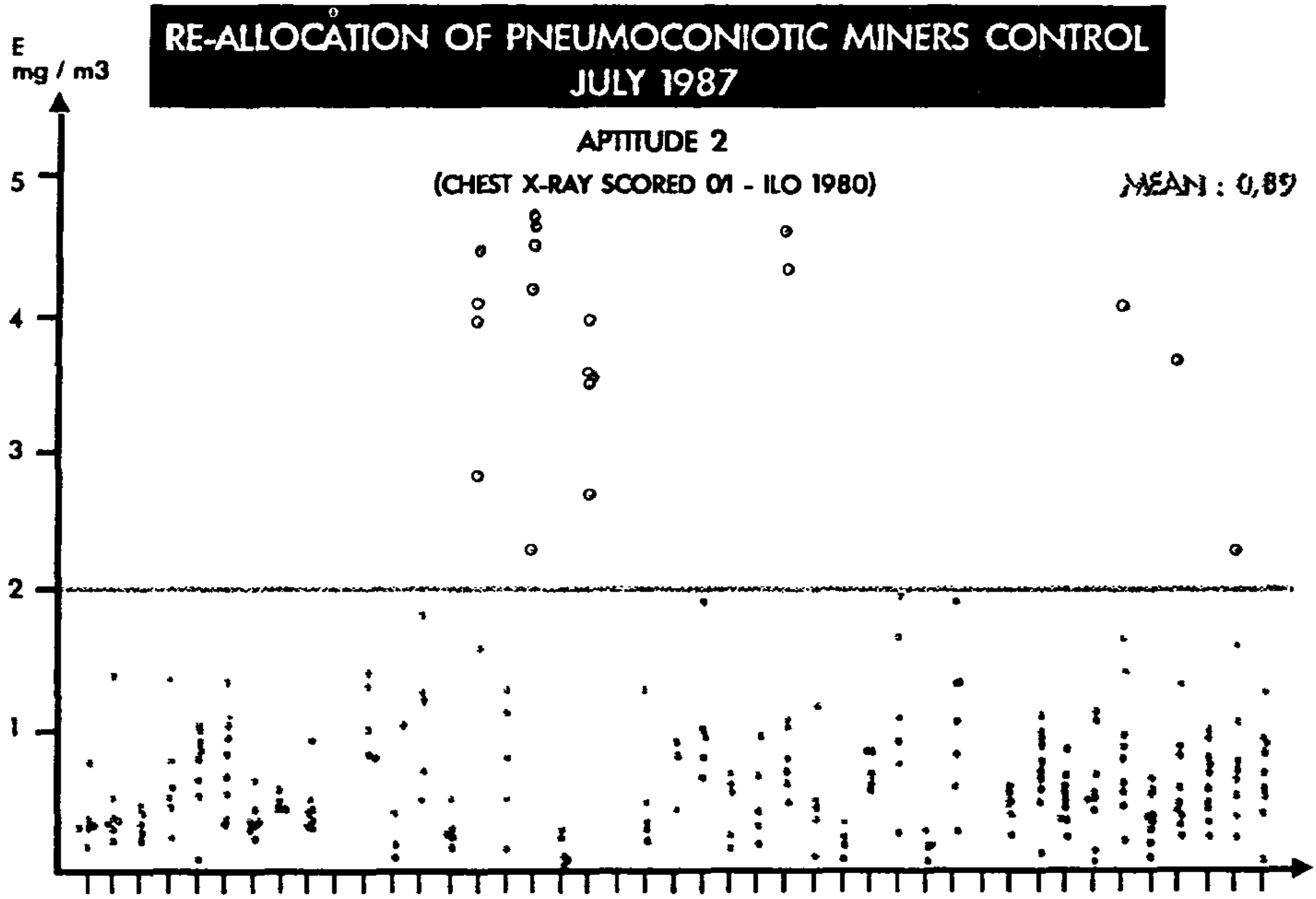
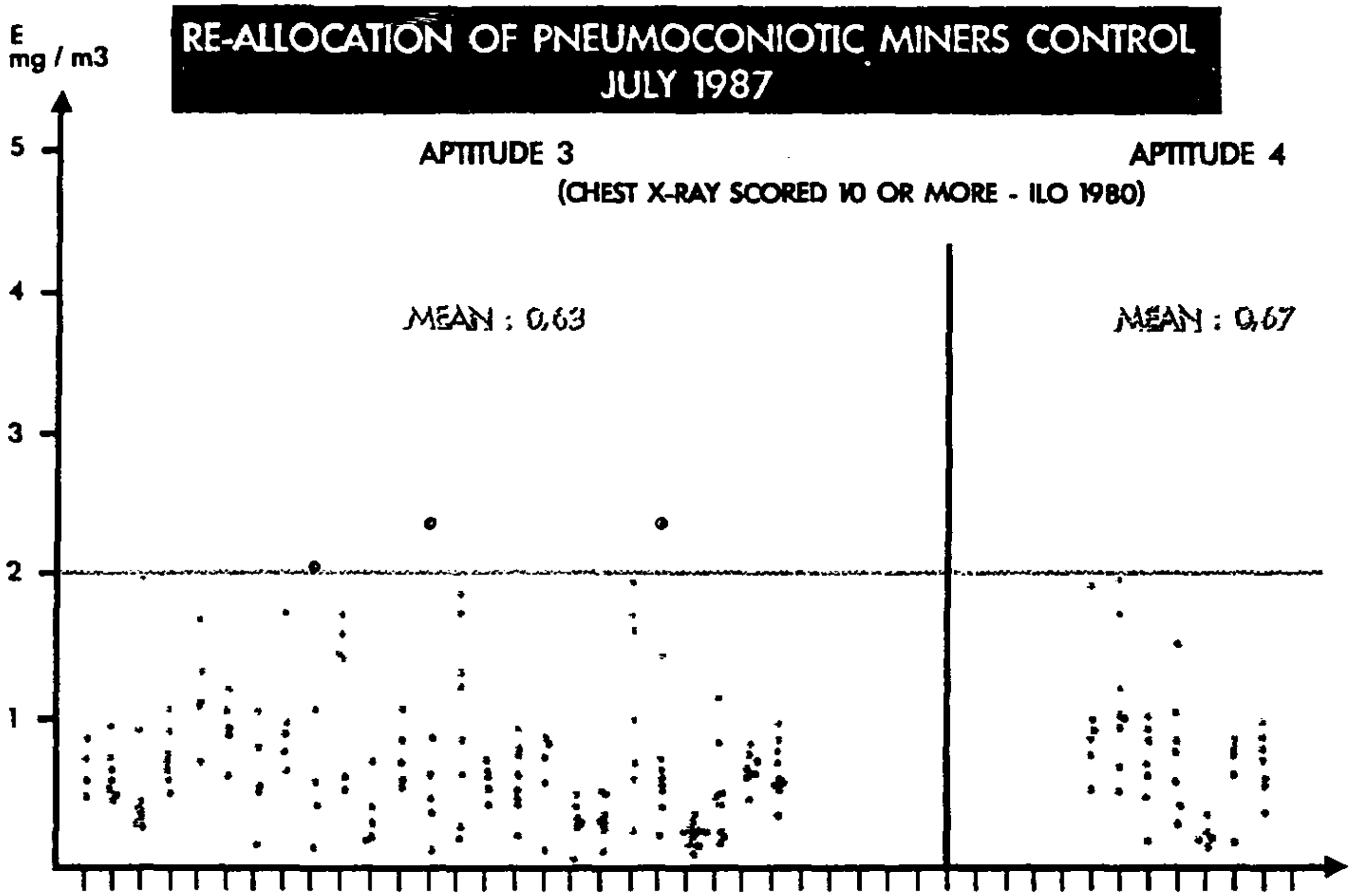


Table VIII
Personal Dust Sampling with the CIP 10



PULMONARY FUNCTION CHANGES IN VERMONT GRANITE WORKERS

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ABSTRACT

Previous studies have suggested that excessive losses of FVC and FEV_1 were occurring in Vermont granite workers despite the fact that quartz levels existing in the industry were below the current OSHA standards. We re-examined these losses in granite workers over an eight year period, testing the workforce semiannually from 1979 to 1987. All workers, including stone shed, quarry and office were offered forced spirometry using a 10 L. Collins water sealed spirometer. In the peak year of participation (1983), 887 workers out of a total of approximately 1400 were tested. Estimates of longitudinal loss were based on 711 workers who participated in at least 3 of the surveys. The mean age of this group was 42.9 years, and the mean years employed was 19.3 yrs. 21.4% were non-smokers (NS), 34.2% ex-smokers (ES), and 44.4% current smokers (CS). Average annual losses of FVC were .025 ±.055 L. (CS: .032 L.; NS: .014 L.; ES: .024 L.). Average annual losses of FEV_1 were .036 ±.040 L. (CS: .044 L.; NS: .027 L.; ES: .033 L.). Analysis of covariance indicated that losses were related to the initial values for FVC or $FEV_{1.0}$, height, age, and smoking history. The losses of both FVC and $FEV_{1.0}$ were not correlated with years employed in the granite industry. The losses of pulmonary function were significantly smaller than those estimated previously, which were .070-.080 L in FVC, and .050-.070 in $FEV_{1.0}$. We conclude that current dust levels in the Vermont granite industry do not accelerate pulmonary function loss.

BACKGROUND

A cross-sectional analysis of pulmonary function loss in Vermont granite workers suggested a small loss in the forced vital capacity (FVC) and FEV_1 due to dust exposure, amounting to 2 ml/year, compared with a 30 ml loss annually due to aging, and a 9 ml loss due to smoking.[1] Although these results were criticized as resulting in a negligible loss over a working lifetime,[2] a later longitudinal study[3] stated that annual losses of FEV_1 were between 50-70 ml, and FVC losses were between 70-80 ml. These studies suggesting excessive pulmonary function loss related to granite dust exposure (average dust-year 523 micrograms/cubic meter, average quartz year of exposure 50 micrograms/cubic meter) were influential in the current NIOSH recommended exposure limit of 50 micrograms/cubic meter for crystalline silica. The operative OSHA limit is 100 micrograms/cubic meter.

In 1981, we published data[4] concluding that the predicted losses of pulmonary function had not occurred, based on a follow-up study of the same individual workers who had been tested previously. Large increases had occurred in vital capacity values (106 ml year), and there were essentially no losses annually in FEV_1 values. The authors of the previous papers agreed[5] that the FVC measurements were invalid because of short expiratory times, though the decrements of FEV_1 values continue to be discussed.[6]

This study presents further longitudinal data on pulmonary function losses in the Vermont granite population. The initial survey, done in 1979, was the basis for our 1981 publication. Follow-up industry-wide surveys were carried out semi-annually to 1987, giving an eight year period of observation. The purpose of the study was to characterize the rate of pulmonary function change and to determine whether exposure to the relatively low levels of granite dust prevailing in the industry significantly affect pulmonary function loss.

METHODS

All employees in the Vermont granite industry, which includes approximately 70 stone sheds and 6 quarries in 5 different communities, were offered forced spirometry semiannually from 1979 to 1987. In 1983 these tests were carried out in conjunction with a chest radiographic survey. Job categories included the various stone shed jobs (polisher, cutter, planer, wire saw, etc.) as well as outdoor quarry workers and office workers. Spirometry was performed on a 10 L. water-sealed Collins spirometer according to recommendations of the Epidemiology Standardization Project.[7] Values for FVC and FEV_1, ambient temperature, age, years employed in the industry, and smoking history were recorded for each worker. In addition, analysis of total gravimetric dust levels was carried out using personal breathing zone samplers. Data were analyzed using basic univariate analysis, as well as analysis of covariance.

RESULTS

The numbers of workers tested in the semi-annual surveys is given in Table 1. The numbers listed for 1979 are artifactually low, since the initial 150 workers tested were excluded because they had been tested on a different instrument which was not precisely calibrated. Subsequent spirometries were performed on the Collins spirometer used by the previous workers from 1970-74. In addition, approximately 100 tracings have been lost and are not available for analysis. Only 173 workers were tested on all five occasions over an eight year period, reflecting the fact that new workers were coming into the work force, others were retiring or were unavailable for testing because of vacation, sick leave or a mobile van at the work place for the first time since 1976. There were 711 workers who were tested 3 times or more. The basic statistics of this group are listed in Table II. Nearly 80% of the workers were either ex-smokers or current smokers; only 21.4% were never smokers. The average number of years in granite was nearly 20.

Longitudinal pulmonary function changes are based on the 711 subjects, both shed and quarry workers, who were tested three or more times. This data is summarized in Table III. Yearly decrements in FEV_1, FVC and $FEV_1/FVC \times 100$ were estimated for each worker as the slope of the fitted least squares regression line for each individual. These slopes were approximately normally distributed and smokers exhibited more function loss than non-smokers and ex-smokers. Overall annual losses were .025 L.for FVC, .036 L. for FEV_1, and 0.37% for the FEV_1/FVC ratio. Non-smokers have the lowest losses, ex-smokers intermediate, and current smokers the highest losses. Within different smoking categories (non-smoker, ex-smoker, and current smoker), there was no difference in losses between exposure categories we presume to be different, i.e. office, shed and quarry workers. Decrements in lung function appear to be similar to those reported in other working populations not exposed to dust in the occupational environment, and are clearly far lower than the estimates of longitudinal loss reported previously among Vermont granite workers.

To separate out the effects of independent variables (age, value of initial measurement, smoking status and granite working history), we carried out an analysis of covariance. For the FVC and FEV_1, the independent variables of initial FVC, height, age and smoking had a significant effect on pulmonary function changes ($p<.001$ or less), whereas "years in granite," used as an index of granite exposure, had no significant effect ($p=.144$ for FVC and .151 for FEV_1).

DISCUSSION

These results indicate that the previous estimates of pulmonary loss in Vermont granite workers were probably in error, and we attribute the conflicting results to the fact that our spirometric measurements were techically rigorous, with careful attention to duration of expiration, calibration of the spirometer, and assuring maximum voluntary effort. Our analysis of dust levels in the stone sheds suggest that no change has occurred in the industry since 1970-78. The mean dust concentration was 601 micrograms/cubic meter, which is quite similar to the results reported previously.[8] Accepting the quartz levels at 10%, as stated by the previous workers,[8] the average quartz exposure estimates are 60 micrograms/cubic meter, which is below the current OSHA limit, but above the recommended exposure limit of 50 micrograms/cubic meter proposed by NIOSH. We conclude that current pulmonary function losses are comparable to those seen in non-dust exposed working populations, and that current dust exposures in the granite industry do not contribute to pulmonary function loss. Further, the observed annual losses are approximately half the values reported by previous studies in Vermont granite workers.

Table I
Number of Workers With Data Available
Years Tested

1979	1981	1983	1985	1987	3 or more	all 5
426	613	864	806	661	711	173

Table II
Basic Mean Data of Workers With 3 or More Tests
(All Subjects = 711)

Age in 1983	42.903
Height	68.3
Years in granite	19.336
Mean FEV 1.0., L.	3.687
Mean FVC, L.	4.804
Mean FEV 1.0/FVC	.766

Table III

Mean Annual Longitudinal Losses in Pulmonary Function Parameters in 711 Workers Tested 3 or More Times

	Smokers N=316	Ex-smokers N=243	Non-smokers N=152	All n=711
FVC, L.	.032	.024	.014	.025
FEV 1.0,L.	.044	.033	.027	.036
FEV 1/FVC x 100	.437	.318	.314	.370

No difference was found in annual losses of FEV 1.0 and FVC between office, quarry and stone shed workers overall or in different smoking categories.

REFERENCES

1. Theriault, G.P., Peters, J.M., Fine, L.J.: Pulmonary Function in Granite Shed Workers of Vermont. *Arch. Environ. Health.* 28:23-27 (1974).
2. Morgan, W.K.C.: The Walmus and the Carpenter of the Silca Criteria Standard. *J. Occup. Med.* 17:782-3 (1975).
3. Musk, A.W., Peter, J.M., Wegman, D.H., Fine, L.J.: Pulmonary Function in Granite Dust Exposure: a Four Year Follow-up. *Am. Rev. Resp. Dis.* 115:769-76 (1977).
4. Graham, W.G.B., O'Grady, R.V., Dubuc, B.: Pulmonary Function Loss in the Vermont Granite Workers. *Am. Rev. Resp. Dis.* 123:25-28 (1981).
5. Wegman, D.H., Eisen, E., Peters, J.M.: Letter to the Editor. *Am. Rev. Resp. Dis.* 128:776-777 (1983).
6. Eisen, E.E., Wegman, D.H., Louis, T.A.: Effects of Selection in a Prospective Study of Forced Expiratory Volume in Vermont Granite Workers. *Am. Rev. Resp. Dis.* 128:587-591 (1983).
7. Ferris, B.G.: Epidemiology Standardization Project. *Am. Rev. Resp. Dis.* 118:1-120 Part 2 (1978).
8. Eisen, E.A., Smith, T.J., Wegman, D.H., Louis, T.S., Froines, J.: Estimation of Long Term Dust Exposures in the Vermont Granite Sheds. *Am. Ind. Hyg. Assoc. J.*: 45:89-94 (1984).

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ARBEITSMEDIZINISCHE VORSORGEUNTERSUCHUNGEN FÜR QUARZFEINSTAUBGEFÄHRDETE BESCHÄFTIGTE IN DER BUNDESREPUBLIK DEUTSCHLAND

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In der Bundesrepublick Deutschland müssen alle Beschäftigten, die an ihrem Arbeitsplatz durch Quarzfeinstaub gefährdet werden, vor Beginn ihrer Tätigkeit und danach in regelmaßigen Abständen arbeitsmedizinisch untersucht werden. Wann kann von einer Gefährdung gesprochen werden? In der Bundesrepublik Deutschland ist für Quarzfeinstaub in der Atemluft der Beschäftigten am Arbeitsplatz eine Schadstoffkonzentration von o, 15 mg/m^3 zulässig. Dieser Wert setzt voraus, daß nur gesunde Personnen dieser Schadstoffkonzentration ausgesetzgt werden. Daraus folgt, daß Beschäftigte schon bei weitaus niedrigeren Schadstoffkonzentrationen arbeitsmedizinisch überwacht werden müssen. In der Bundesrepublik Deutschland ist diese Auslöseschwelle auf die Hälfte des oben genannten Grenzertes festgelegt worden.

Die arbeitsmedizinischen Untersuchungen müssen vor Ausnahme der Tätigkeit (Erstuntersuchung) und danach in regelmaßigen Abständen (Nachuntersuchungen) wiederholt werden. Die Untersuchungen selbst dürfen nur von besonderes erfahrenen und ermächtigten Ärzten vorgenommen werden. Sofern diese keine kürzeren Zeiträume vor schlagben, erfolgen die Untersuchungen bei quarzfeinstaubgefährdeten Beschäftigten in Abständen von 3 Jahren. Nur wenn und solange der Arzt keine Bedenken erhebt, dürfen die Beschäftigten dan ihrer Arbeit weiter nachgehen.

Der Unternehmer hat die Untersuchungstermine zu überwachen, die Untersuchungen zu veranlassen, zu bezahlen und auch für jeden Beschäftigten eine Gesundheitskartei zu führen. In dieser Kartei sind neben den persönlichen Daten festzuhalten:

- Tag der Einstellung und des Ausscheidens,
- Art der Gefährdungsmöglichkeiten,
- Art der Tätigkeit mit Angabe des Zeitpunktes ihres Beginns und ihres Endes,
- Angaben von Zeiten über frühere Tätigkeiten, bei denen eine Gefährdungsmöglichkeit bestand,
- Datum und Ergebnis der arbeitsmedizinischen Vorsorgeuntersuchungen.

Die Steinbruchs-Berufsgenossenschaft, der Träger der gesetzlichen Unfallversicherung auch für die Steinbrüche, hat seit Jahrzehnten gleichsam als Serviceleistung—für ihre Mitglieder die Terminüverwachung dieser ärztlichen Untersuchungen und die Aufbewahrung der Röntgenaufnahmen und sonstigen Unterlagen übernommen. So sind für alle quarzfeinstaubgefährdeten Beschäftigten lückenlos für die Dauer ihrer Tätigkeit in einem Mitgliedsunternehmen Unterlagen vorhanden, die bei einer beginnenden oder festgestellten Erkrankung für die Beurteilung herangezogen werden können. Dies ist gerade im Hinblick auf die Vielzahl der ganz kleinen Steinbrüche von sehr großer Bedeutung, da diese Betriebe selbst kaum in der Lage sind, die vorgeschriebenen Karteien zu führen und die Unterlagen aufzubewahren.

Im Jahr 1986 hat die Steinbruchs-Berufsgenossenschaft begonnen, alle Daten EDV-mäßig zu erfassen. Seitdem erhält jeder Betrieb, in dem Staubgefährdete versichert sind, 2 Monate vor Ablauf der Untersuchungsfrist eine Benachrichtigung, daß eine weitere Untersuchung vorgenommen werden muß. Dieser Benachrichtigung werden nicht nur die notwendigen Formulare, sondern auch eine Liste der in der näheren Umgebung tätigen und von der Berufsgenossenschaft ermächtigten Ärzte beigefügt. Auf diese Weise hat der Beschäftigte die freie Arztwahl. Nach der Untersuchung werden die Röntgenaufnahmen und die ärztliche Beurteilung der Berufsgenossenschaft zur Aufbewahrung übergeben. Diese legt schließlich alle Unterlagen, die über einen Beschäftigten vorhanden sind, einem besonders ausgebildeten und geübten Arzt zur endgültigen Beurteilung vor. Diese Ärzte besitzen nicht nur eine langjährige Berufserfahrung als Lungenfachärzte, sondern haben sich durch die Vielzahl der Fälle, die ihnen vorgelegt werden, ein besonders umfangreiches Wissen um die Silikose erworben. Jeder dieser Ärzte begutachtet im Jahr etwa 2.000 Personen. Nicht selten kann ein Arzt 1o bis 15 Röntgenaufnahmen desselben Beschäftigten zum Vergleich heranziehen. Dieser Arzt entscheidet auch, ob der Beschäftigte weiterhin seiner bisherigen Tätigkeit nachgehen kann, ob die übliche Untersuchungsfrist von 3 Jahren verkürzt werden muß und ob ein Beschäftigter gegebenenfalls seinen Arbeitsplatz wechseln mß. Etwa 20.000 Beschäftigte, die staubgefährlich tätig sind, werden auf diese Weiseüberwacht.

Entscheidend für den Grad der Gefährdung eines

Beschäftigten ist neben seinem Gesundheitszustand auch die Höhe der Schadstoffkonzentration in der Atemluft am Arbeitsplatz. Für die Arbeitsmedizin ist es sicherlich von sehr großem Interesse, diese beiden Daten einander gegenüberzustellen bzw. zu verknüpfen, um eine noch verläßlichere Beurteilung der Grenzwerte zu erhalten. Die Steinbruchs-Berufsgenossenschaft ist diesem Ziel schon bereits ein großes Stück nähergekommen. Seit Jahrzehnten wird eine Zielzahl von Staubmessungen am Arbeitsplatz durchgeführt und ausgewertet. Im Jahr 1987 wurde nun mit der Zusammenführung der medizinischen und meßtechnischen Daten begonnen. Dabei wurde zunächst besonderer Wert auf eine möglichst exakte Beschreibung des Arbeitsplatzes und Tätigkeit des einzelnen Beschäftigten gelegt. Bei Wechsel des Betriebes oder Aufnahme einer anderen Tätigkeit werden diese Daten aktualisiert. Auf diese Weise wissen wir schon heute nicht nur, ob ein Beschäftigter gesund ist, sondern seit wann er einer bestimmten Schadstoffkonzentration ausgesetzt ist. Wir beabsichtigen, dieses Verfahren forfzuführen, so daß wir schließlich für diese Beschäftigten über ihr ganzes Arbeitsleben hinweg die entsprechenden Daten haben. Da nicht nur der Arbeitsplatz, sondern auch die Tätigkeit genau beschrieben und verschlüsselt sind, wird es uns künftig auch möglich sein, einzelne Personengruppen daraufhin zu untersuchen, ob sie stärker gefährdet sind als andere.

Der Vollständigkeit halver möchte ich noch erwähnen, daß die Steinbruchs-Berufsgenossenschaft auch einen Röntgenwagen besitzt, der in die Betriebe fährt und dort an Ort und Stelle die Nachuntersuchungen durchführt. Dadurch ist gewährleisted, daß diese Untersuchungen zum vorgeschriebenen Zeitpunkt nahezu lückenlos durchgeführt werden und andererseits den Betrieben beträchtliche Kosten für die Arbeitsunterbrechung erspart bleiben.

PREVALENCE OF RADIOGRAPHIC SMALL LUNG OPACITIES AND PLEURAL ABNORMALITIES IN A REPRESENTATIVE SAMPLE OF ADULT FINNS

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ABSTRACT

This study is part of the Mini-Finland Health Survey which was carried out in a sample (n=8000) representative of the Finnish population aged 30 or over. The aim of the study was to investigate the prevalence or radiographic small lung opacities and pleural abnormalities in this population. Of the standard full size radiographs routinely taken, 7095 (89% of the sample) were acceptable for classification purposes. Two radiologists recorded the findings independently according to the ILO (1980) Classification of Radiographs of Pneumoconioses. The prevalences were calculated on the basis of findings agreed on by the two radiologists.

The prevalences of small lung opacities and pleural abnormalities all increased steeply with age and were much higher in men than in women. The prevalences (%, age-adjusted) of the most common findings are given in the table.

	Men	Women
	16.5	10.0
Small opacities (at least category 1)	13.8	3.2
Diffuse pleural thickening		
Pleural plaques	10.2	2.6
Pleural calcification	6.6	2.3

The divergent prevalences in men and women are probably related to differences in working conditions and smoking habits which are currently subject to further analysis. These population based findings are likely to constitute a useful basis for various reference purposes.

No Paper provided.

OCCUPATIONAL ASTHMA IN MEAT WORKERS EXPOSED TO PROTEOLYTIC ENZYMES

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ABSTRACT

In January, 1987, work-related shortness of breath and wheezing among workers at a meat portioning facility prompted a request for a NIOSH health hazard evaluation. The facility sprays steaks with spice solutions containing the enzymes papain, bromelain, and ficin. Occupational asthma related to enzyme exposure had not previously been reported in the meat industry.

To identify individuals with symptoms compatible with occupational asthma, we administered a case-finding questionnaire to 376 of 400 current workers. Ninety-six workers with compatible symptoms, and an equal number of non-symptomatic workers, were invited to participate in a set of follow-up examinations, which included a more detailed questionnaire, pulmonary function testing, skin prick testing, and assays for specific IgE to papain. Ninety-six workers participated in the follow-up. Twenty-one (23%) of 91 skin-tested workers reacted to at least one of the purified enzymes. Eight (11%) of 73 participants completing peak-flow measurements had evidence of symptomatic, work-related bronchial lability. Based on the medical studies, we diagnosed 29 workers with possible or definite tenderizer-related occupational asthma. This corresponds to a prevalence of 12% among workers exposed to tenderizers. This study demonstrated that IgE-mediated sensitization to proteolytic enzymes, and tenderizer-related asthma can occur in the meat industry.

No Paper provided.

THE EFFECTS OF AGRICULTURAL DUSTS ON HUMAN HEALTH IN SHANGHAI AREA

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SUMMARY

From 1985 through 1987, the surveys of several kinds of agricultural dusts, including rice, tea, hay and mushroom compost, on human health have been conducted in Shanghai. Totally, 1851 subjects were investigated. There were some disorders related to the exposure to the dusts, including stimulation symptoms on mucous membrane of airway (0.8–63.4% in them), grain fever (5.1–17.5%), hypersensitivity pneumonitis (3.5–5.8%), chronic bronchitis (4.3–17.7%) and some changes of pulmonary function. Some potential etiological agents and mechanisms were studied in the survey. The findings show that these dusts have affected human health.

INTRODUCTION

It is well known that agricultural dusts are harmful to human health.[1] From 1985 through 1987, some field surveys were conducted in the Shanghai area in order to find out their effects on human health and to study some of the potential etiological agents and the mechanisms of the effects.

METHODS AND MATERIALS

Dust Concentrations in Air

The total airborne dust concentrations in workplaces were determined by using the dust collectors of DK-60-2 type and conventional method.

The Amount of Thermoactinomycetes

In order to determine the amount of thermoactinomycetes in air, LWC-1 centrifugal collectors of airborne microorganisms were used to collect microoganisms in various workplaces of cultivating mushrooms. The samples were incubated at 52°C and the colonies were counted every day through the fifth day. Finally, the thermoactinomycetes were identified morphologically.

Subjects

1851 subjects were investigated, including 349 rice processors, 259 tea workers, 746 rice farmers and 497 mushroom farmers. The controls were not exposed to dust in the same area.

Questionnaire and Pulmonary Function Test

The modified questionnaires were applied for interview to the subjects and controls.[2] The pulmonary function tests were performed by using spirometer of LR-80 type in most of them, but the tests were done by using Collin's spirometer in mushroom farmers and their controls.

Immunological Test

ELISA was applied to determine the level of IgE in serum from the tea workers and the precipitins in serum were tested in mushroom farmers and their controls.[3,4]

RESULTS

The Environmental Study

The geometric means of airborne dust concentration in different workplaces have been found to be from 13.2 to 76.9 mg per cubic meter in rice processing mills and from 2.3 to 36.4 mg per cubic meter in the tea mills. In addition, the geometric means of the amount of thermoactinomycetes have been found to be from 1.07×10^4 to 4.39×10^5 CFU per gram of the compost of mushrooms and from 262 to 3276 CFU per cubic meter of air in the workplaces of cultivating mushrooms during the work except the duration of picking mushrooms, but only from 13 to 42 CFU per cubic meter of air in control places.

Response to The Dusts

The prevalence of stimulation symptoms on mucous membrane was 63.4% in rice processors, 53.7% in tea workers, 29.8% in rice farmers and only 0.8% in mushroom farmers. Meanwhile, the prevalence of grain fever was 17.5% in rice processors and 5.1% in rice farmers, being significantly different between them ($P < 0.05$). However, the hypersensitivity pneumonitis (HP) was not found in rice processors. The prevalence of HP (farmer's lung) was 3.5% in rice farmers and the prevalence of mushroom worker's lung, another kind of HP, was 5.8% in mushroom farmers, the latter being significantly higher than the former ($P < 0.05$).

The prevalence of chronic bronchitis in male and female rice processors was the highest (17.7 and 9.9%) of all male and female groups ($P < 0.01$ and $P < 0.05$). The prevalence (in male and female respectively) was 10.6 and 4.3% in rice farmers, 6.7 and 5.5% in mushroom farmers, 2.2 and 1.0% in controls. The prevalence in the tea workers of two mills was 5.6 and 6.0%, respectively.

Pulmonary Function Test

The ratio of the observed to the predicted (O/P) FEV_1, V_{75}, V_{50} and V_{25} declined in different groups. The values of FVC, FEV_1, V_{50} and V_{25} declined after shift compared with those before the shift in female tea workers significantly and the FEV_1 also declined in female rice processors, but not significantly. It was also shown that the values of FEV_1, FVC and $FEF_{25\text{-}75\%}$ decreased significantly in the farmers after the season of cultivating mushrooms.

Immunological Test

The average levels of total IgE in serum from the tea workers in the two mills were significantly higher (490.83 and 539.63 IU per ml) than that (290.03 IU per ml) from the controls. Moreover, the prevalence of precipitin reaction against antigens from *T. candidus* 106 and *T. vulgaris* 941 was significantly higher (64.7 and 41.2%) in mushroom farmers than that (6.0 and 8.4%) in controls.

DISCUSSION

The Maximum Allowable Concentrations of airborne rice and tea dusts in the workplace are 10 mg per cubic meter and 3 mg per cubic meter in China, respectively.[5] In these surveys, most of the samples of airborne dusts had concentrations higher or much higher than the MACs. The rice processors and tea workers were exposed to the high concentration of dust at work every day, which probably was the main cause of the high prevalence of stimulation symptoms on mucous membranes. The rice farmers were only exposed to the rice dust outdoors in the harvest season, so their exposure might not be as serious as the processors and workers. Since the compost of mushrooms was rather wet, there was not so much dust from it, but the aerosol containing microorganisms might generate from it. Therefore, the prevalence of the symptoms in the farmers was not as high as that in the processors and workers.

The prevalence of chronic bronchitis increased in pace with smoking and age.[6] Although, there was no significant difference of age and smoking habit between male rice processors and other subjects, the prevalence of chronic bronchitis was higher in them than in others. There were almost no women smokers in Shanghai and the average age of female rice processors was younger than that of others, but the prevalence in them was higher than that in others. In addition, the prevalence in every group of subjects was higher than that in controls. Therefore, the chronic bronchitis in the subjects might be related to their exposure to the agricultural dust, especially to the rice dust in the processing mills.

The prevalence of grain fever in the rice processors was higher than that in rice farmers, which could be related to the fact that exposure to dust was more severe in the former than in the latter. But there was little mouldy rice in the rice processing mills, so the HP was not found in the mills. However, since the rice farmers were not only exposed to the rice dust, but also to mouldy hay dust sometimes, the prevalence of HP (farmer's lung) was 3.5% in them. The mushroom farmers might be exposed to more amounts of thermoactinomycetes in the aerosol from the compost of mushrooms than the rice farmers, thus, the prevalence of HP in them was higher than that in the rice farmers.

Many of the subjects exposed to the agricultural dusts have had some damage of pulmonary function. The changes were obvious in tea workers, which appeared to be obstructive in airway. FEV_1 and FVC decreased, but FEV_1/FVC did not in some mushroom farmers after a cultivating season, which might be consistent with the change of HP.[7]

Mushroom farmers were mainly exposed to thermoactinomycetes like *T. vulgaris*, but not to *M. faeni*, and the precipitins in serum from them were mainly against *T. candidus* and *T. vulgaris* but not against *M. faeni*. So, the main antigens of HP might be from *T. vulgaris* and related taxa, which is probably similar to the findings of the etiological study of farmer's lung in other districts of China.[8]

In addition, the level of IgE in serum was raised in some tea workers who had some respiratory symptoms related to exposure to tea dust, which might imply that some symptoms were possibly related to the mechanism of allergy.[9]

It could be concluded that these agricultural dusts had affected human health in Shanghai. Some preventive measures should be taken such as supression of dust and mould, personal protective measures, and so on.[10]

REFERENCES

1. Parkes, W.R.: *Occupational Lung Disorders*, 2nd Ed., pp. 359-402. Butterworths, London (1982).
2. Lu Pei-lian et al.: Several Links in the Survey of Byssinosis. *Chinese J. Industr. Hyg. Occup. Dis.* 2:120-125 (1984).
3. Zhou Tong et al.: Level of IgE in Human Serum Determined by ELISA. *Chinese J. Microbiol. Immunol.* 1:48-53 (1981).
4. Shen Yi-e et al.: A Primary Study of Causative Agents of Farmer's Lung in Dafeng County. *Chinese J. Industr. Hyg. Occup. Dis.* 5:377 (1987).
5. Lu Pei-lian and Gu Xing-yuan: *Preventive Medicine*, 1st Ed., pp. 275-277. Shanghai First Medical College, Shanghai (1984).
6. Guo De-long: Smoking and Health. *Chinese J. Tuberculosis Respir. Dis.* 3:121-122 (1980).
7. Shen Yi-e and Lu Pei-lian: Some Views on the Diagnostic Criterion of Farmer's Lung. *Chinese J. Industr. Hyg. Occup. Dis.* 5:110 (1987).
8. Lu Yun-yu et al.: Studies on Pathogens of Farmer's Lung in Jiangsu—Isolation and Classification of Thermophilic Actinomycetes. *Acta Microbiologica Sinica* 25:351-355 (1985).
9. Zuskin, E. et al.: Immunological and Respiratory Changes in Tea Workers. *Int. Arch. Occup. Environ. Health.* 56:57-65 (1985).
10. Tao Bing-gen et al.: An Epidemiological Study on Farmer's Lung in Dafeng County, Jiangsu Province. *Chinese J. Industr. Hyg. Occup. Dis.* 2:34-38 (1984).

OCCUPATION INDUCED PULMONARY DISEASE IN A WAFER BOARD MANUFACTURING PLANT, COLORADO

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ABSTRACT

In December 1986 the Colorado Department of Health requested assistance from the National Institute for Occupational Safety and Health in evaluating a cluster of asthma cases among employees of a wafer board manufacturing plant. The plant reduces aspen logs to thin wafers, which are then pressed into rigid waferboards using MDI (4,4-diphenylmethane diisocyanate) as the binding agent. A cross-sectional survey of 97 current employees and directed review of 93 former employees identified 13 cases of disease for an overall attack rate of 6.7%. The attack rate among current employees was 3%, while the attack rate among farmer employees was 11%. Personal air samples for MDI were within NIOSH's standard (5 ppb), suggesting that our cases represent sensitized individuals. To identify risk factors associated with disease a case control study was undertaken. No association was found between family or personal history of asthma, eczema, hayfever, smoking, or job title. Given our inability to find any predictive pre-employment screening tests, nor identify any particular area or job title with MDI exposure, surveillance of the current workforce for early MDI sensitization is very important. Symptom questionnaires, peak expiratory flow readings, MDI-ELISA and RAST tests, could all be used.

No Paper provided.

BYSSINOSIS: RESPIRATORY PROBLEMS AMONG COTTON TEXTILE MILL WORKERS IN ETHIOPIA

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INTRODUCTION

Although occupational lung disorder caused by inhalation of cotton dust is a continuing problem and byssinosis is now known to occur worldwide, cotton production and consumption has expanded rapidly in developing countries. The People's Democratic Republic of Ethiopia being one of the cotton producers and consumers countries in Africa, started expanding its textile industries since the last decade and the number of its workers in cotton processing continues to grow annually.

Lots of studies in cotton mills were done and reported from many developed nations and also few reports regarding respiratory problems have been documented from developing countries like Egypt,[1] Sudan,[2] Tanzania,[3] and Hong Kong,[4] but there is no article published concerning the problems caused by cotton dust in Ethiopia. Thus, this paper represents the first epidemiological study of the textile industry in Ethiopia using diagnostic criterion similar to those which are applied in developed countries, such as the United States of America and Great Britain.

A few studies of cotton textile workers have looked into the prevalence of respiratory symptoms and lung function compared with those of control subjects.[5,6,7,8] There is also a limited number of studies that have reviewed lung function in cotton textile workers with and without byssinosis or bronchitis.[9,10,11] This study investigated the prevalence of byssinosis and other respiratory problems among workers exposed to cotton dust in a textile mill in Ethiopia and also attempted to explore determinants by considering workers exposed to cotton dust in the textile mill with respiratory tract diseases as case study group and without respiratory tract disease as control group.

This cotton textile mill was established in the early 1960s and a daily eight hourly system is operating continously for the whole week, while intermittently providing a "day-off" for each worker to rest. In spite of the attempt to retrofit current ventilation systems in the early 1980s, plant officials stated that the dusty environment remained unchanged since the early 1960s.[12]

MATERIAL AND METHODS

Population

This study included a group of randomly selected 595 workers (322 male and 273 female) representing 40.5% of workers involved in dusty operations in the blowing, carding, drawing, simplex, ringframe, preparatory and weaving sections of a cotton textile mill in Bahir Dar, Ethiopia.

Environmental Assessment

The concentration of airborne dust in the breathing zone was determined with the casella personal dust sampler and the sampling rate was set to 0.2 1/min. The concentration of airborne dust in the general environment was concurrently monitored with an Anderson dust sampler fitted with a vertical elutriator (General Metal Works Inc.) that was set up at a height of 1.5m at selected positions and samples were drawn at a rate of 7.41/min. Multiple area samples were taken and the duration of sampling ranged between 8-10 hours (mean 8.7 hours). All samples were collected on What man glass fibre GF/A with 3.7 cm diameter and weighing was done on a calibrated analytical balance before and after sample collection after equilibrating filters in the laboratory for 24 hours.

Interviews and Physical Examination

A modified version of the British Medical Research Council Questionnaire was filled out and each worker was fully examined with emphasis being laid on signs and symptoms suggestive of respiratory diseases. All workers were blindly interviewed and examined by one trained physician. The stages of byssinosis were defined according to the clinical grades suggested by Schilling et al.[13] Subjects were also diagnosed as having other respiratory diseases based on previously stated criteria.[14,15,16] Subjects who gave confirmed past history of respiratory diseases were also considered in this study.

Pulmonary Function Test

Subjects' forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) were measured under the direction of a technician using a multipurpose spirometer.

Function testings were carried out on each worker on the first day of the shift after at least one day absence from work and repeated at the end of the same shift. Five expiratory efforts were recorded and the mean of the two highest values was used to estimate the FEV_1 and FVC. All volumes were adjusted to body temperature and pressure saturated with water vapour (BTPS). The preshift FEV_1 values were compared with the expected normal values of Cherniack and Rater.[17]

For all statistical tests, P less than 0.05 was considered significant.

RESULTS

Population

All the 595 workers in the study voluntarily underwent interview, physical examination and pulmonary function testing. Non-reproducible function tests of 32 subjects were excluded only from pulmonary function test analysis. There were only 14 smokers and 4 ex-smokers, all male. Over 95% of the cotton workers had not changed jobs or their sections during the course of their employment.

Environmental Assessment

The concetrations of airborne cotton dust are shown in Table I. The highest concentration of cotton dust was recorded in the blowing and carding sections, whereas the lowest was recorded in the weaving and preparatory sections. The amount of dust generated in the blowing and carding operations was high and more than two fold compared to other operations ($P<0.005$). The mean dust concentration and the mean time-weighted dust concentration were much higher ($P<0.001$) in the case study group than in the control group.

Respiratory Conditions

The prevalence of byssinosis and other respiratory tract diseases is summarized in Table II and Figure 1. The prevalences of byssinosis, chronic bronchitis and bronchial asthma were very high ($P<0.001$) among blowers and carders in comparison to those in other sections. The overall prevalence of hay fever (28.3%) was the highest of all the respiratory problems in the textile mill. Generally, the prevalence of byssinosis, chronic bronchitis and bronchial asthma showed a significant increase with the duration of exposure to cotton dust in the textile mill (Table III). No significant difference was observed in the prevalence of byssinosis between smoking and non-smoking workers, otherwise, the effect of smoking on the prevalence of chronic bronchitis was significant (Table IV). In general, 48.1% of the study population had one or more respiratory tract problems while the remaining 51.9% had neither symptoms and signs nor gave past histories of respiratory tract diseases.

We regrouped the study population in two strata based on the frequency distribution of the time-weighted elutriated dust concentration as those with a high and low cumulative dust exposure and cross tabulated, assuming the present dust levels were more or less similar to the past ones.

The estimated relative risks of developing byssinosis and other respiratory problems in high cumulative cotton dust exposure were statistically significant when compared to low cumulative cotton dust exposure (Table V). Also the estimated relative risk of manifesting symptoms of respiratory impairment was significant in those exposed to high cumulative cotton dust and developed respiratory tract problems when compared with those exposed to low cumulative cotton dust (Table VI).

Pulmonary Function Test Analysis

A statistically significant ($P<0.001$) across-shift decrements in FEV_1 and FVC and also a decrease in the percentage predicted FEV_1 were noted in the case study group when compared with the control group. There was a significant reduction in FEV_1 ($P<0.001$) at the end of the shift, more than 10% and/or 20% among byssinotics when compared with the controls (Figure 2). Also a significant increase in percentage reduction in FEV_1 was noted with an increase in byssinoiss grade. The chronic changes in FEV_1 among exposed workers were further analysed according to Bouhuys et al.[18] While 24% of byssinotics developed FEV_1 moderate to severe chronic changes ($P<0.001$), only 1% of the non-respiratory tract disease group (controls) showed similar changes (Table VII).

Generally, the regression analysis results shown in Tables VIII and IX indicate statistically signficant dose-response relationship between respiratory problems and pulmonary function test results at one hand and current, cumulative and length of exposure to cotton dust at the other.

DISCUSSION

The results of our study showed that the concentrations of airborne cotton dust in the different sections of the surveyed textile mill were very high, with concentrations greatly in excess (nearly 4 to 17 tons) of 0.2 mg/m^3 of dust.[19] This was in accordance with reports on other cotton mills.[2,6,20] Also the dust collected at the early stage of yarn production was very high and this was similar to those reported by others.[2,21,22]

The high prevalence of byssinosis in the blowing and carding processes is similar to those reported by other investigators.[2,23,24] The high prevalence of byssinosis in drawing, simplex and ringframe spinners may be due to the fact that the level of cotton dust was still high in these sections.

Inspite of the controversy surrounding the relationship between the prevalence of byssinosis and the duration of exposure, our study showed a significant increase in the prevalence of byssinosis with duration of exposure. The same relationship had also been observed in Sudan and Egypt.[2,20,21] The progression in the stages of byssinosis in relation to the duration of exposure observed in our finding support previously reported conclusions that the different grades of byssinosis succeed each other in diseased subjects.[2,20,21] Our results also showed that there was a significant association between the prevalence of byssinosis and time-weighted dust concentration. This is in agreement with Fox et al.[25] Our results showed that smoking had no significant relationship with the prevalence of byssinosis, probably because of the small number of smokers in our study. Hence due to this small number, there may be a risk of a type II error.

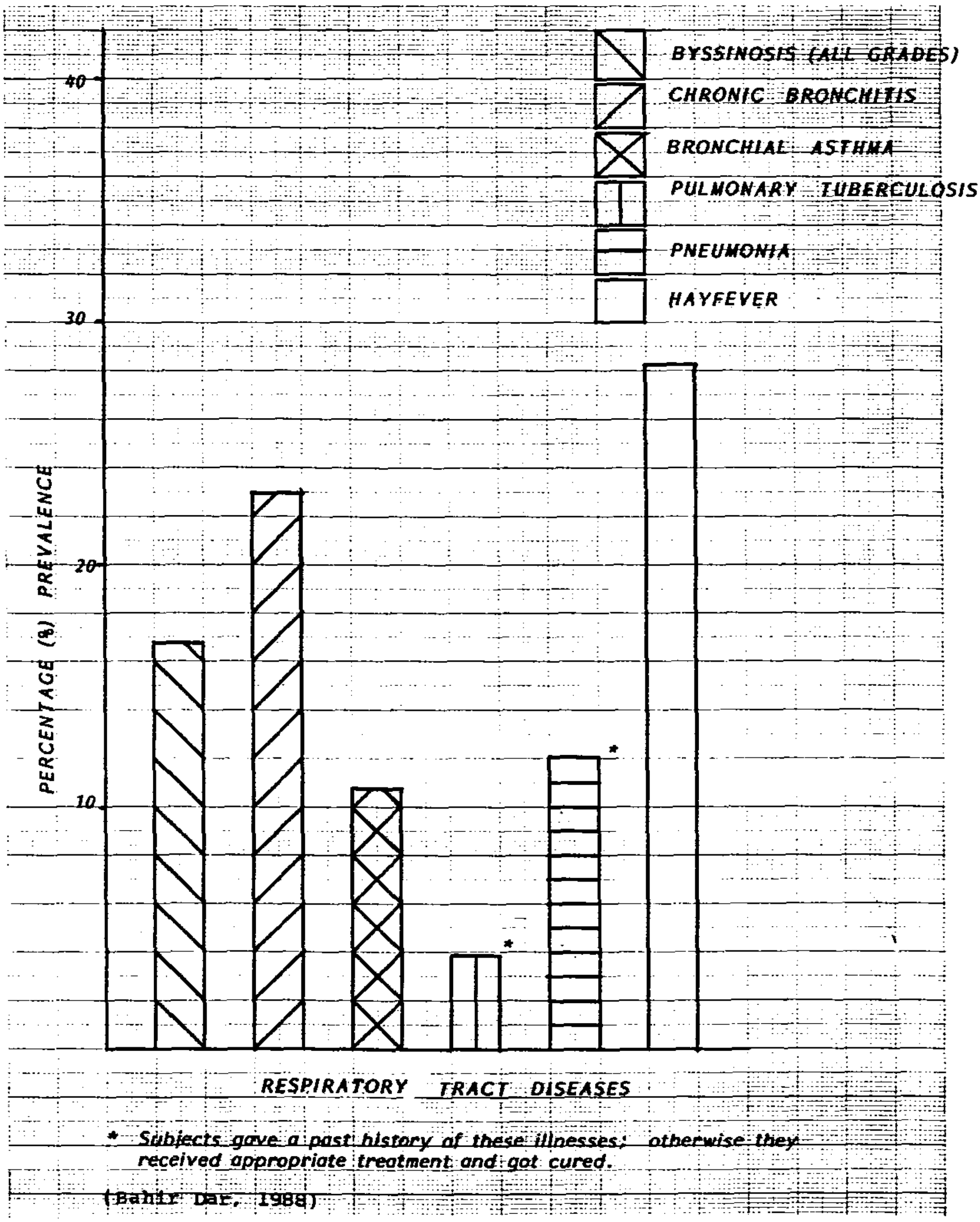

Figure 1. Prevalence of respiratory tract diseases among exposed workers.

Table I
The Concentration of Airborne Cotton Dust in Study Sections
by Area Sampling and Personal Sampling (Mean±SD)

Section	Number of Samples	Area Sampling "Inhalable" Dust mg/m^3	Personal Sampling "Respirable" Dust mg/m^3
Blowing (1)	14	3.52 ± 0.98	3.83 ± 1.06
Carding (2)	18	3.21 ± 1.09	3.58 ± 1.07
Drawing (3)	11	1.62 ± 0.44	1.93 ± 0.23
Simplex (4)	11	1.29 ± 0.32	1.72 ± 0.26
Ringframe (5)	21	1.19 ± 0.49	1.57 ± 0.55
Preparatory (6)	12	0.92 ± 0.23	1.21 ± 0.33
Weaving (7)	25	0.86 ± 0.35	1.03 ± 0.37

Level of Significance	$1V_s2$ P>0.05	$1V_s2$ P>0.05
	$1V_s3$ - 7P<0.0005	$1V_s3$ - 7P<0.0005
	$2V_s3$ - 7P<0.005	$2V_s3$ - 7P<0.0005

(Bahir Dar, 1988)

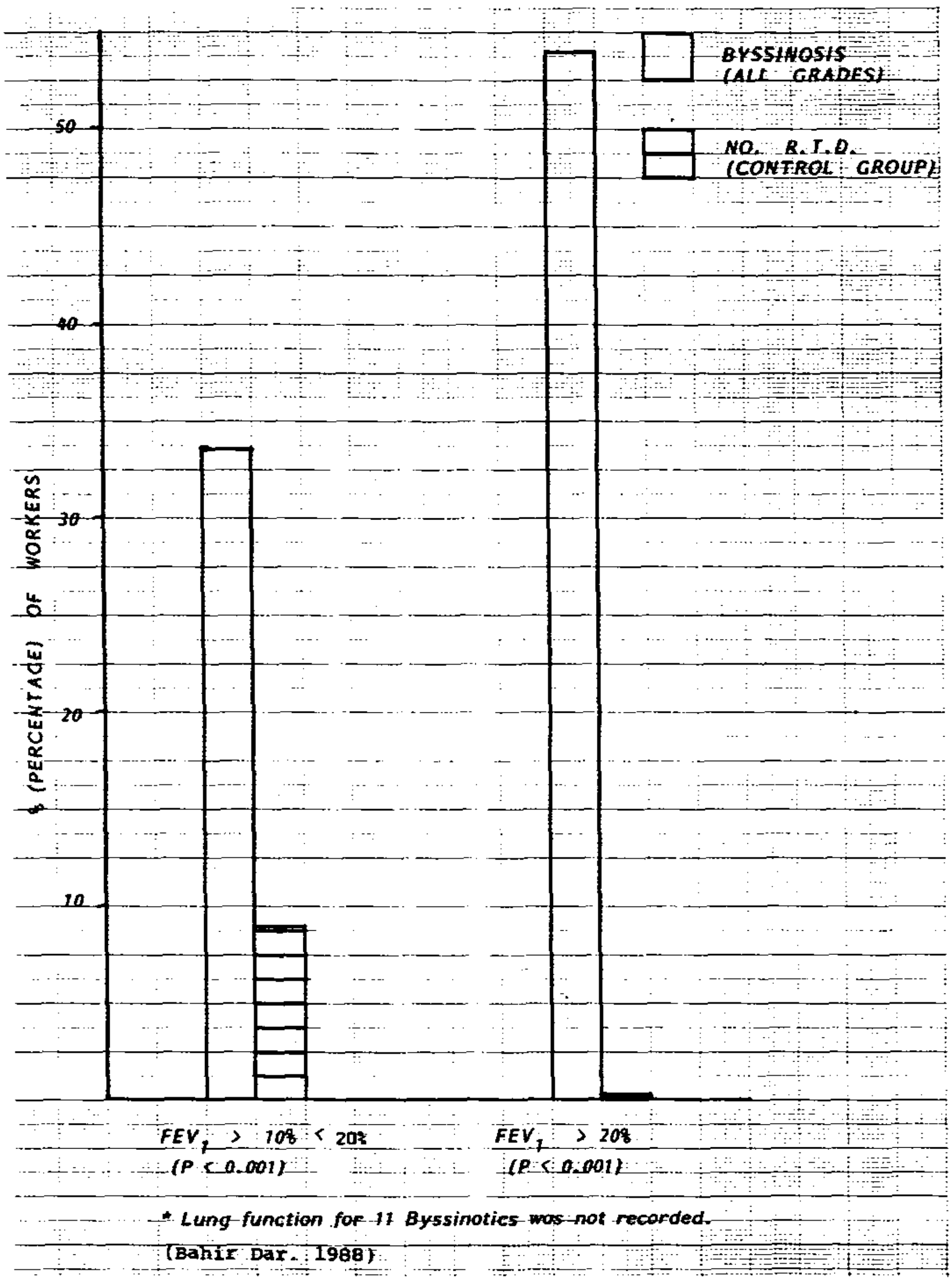

Figure 2. Percent reduction in FEV_1 in examined workers during the first working day after absence from work.*

Table II
The Prevalence of Respiratory Diseases Among Exposed Workers Mean Age and Duration of Exposure

SECTION	Number Examined	Age (Years) Mean ± SD	Duration of Exposure (Months) MEAN ± SD	BYSSINOSIS NO. (%) G½	GI	GII	Total	Chronic Bronchitis No. (%)	Bronchial Asthma No. (%)
Blowing(1)	44	41.3 ± 7.3	201.9 ± 87.2	3(7)	7(15.9)	9(20.5)	19(43.2)*	21(47.7)*	9(20.5)*
Carding (2)	40	41.5 ± 6.9	200.7 ± 74.8	-	2(5)	13(32.5)	15(37.5)*	18(45)*	5(12.5)
Drawing (3)	25	39.9 ± 6.6	239.6 ± 68.5	3(12)	1(4)	2(8)	6(24)	8(32)	3(12)
Simplex (4)	42	40 ± 6.8	235.3 ± 69.4	3(7)	3(7.1)	4(9.5)	10(23.8)	10(23.8)	3(7.1)
Ringframe(5)	174	37.5 ± 6.5	233.1 ±73.2	12(6.9)	9(5.2)	9(5.2)	30(17.2)	32(20.7)	17(9.8)
Preparatory(6)	128	37.1 ± 5.8	222.9 ±71.5	10(8)	-	4(3.1)	14(10.9)	23(18.0)	15(11.7)
Weaving (7)	142	39 ± 4.6	238.7 ± 67	3(2.1)	2(1.4)	1(0.7)	6(4.2)	25(17.6)	12(8.5)
TOTAL	595	38 ± 6.9	218.3 ± 79.5	34(5.7)	24(4)	42(7.1)	100(16.8)	137(23)	65(10.8)

* P< 0.001
(Bahir Dar, 1988

Table III
Duration of Exposure and the Prevalence of Respiratory Diseases

Duration of Exposure (Years)	Number Examined	BYSSINOSIS NO (%) G½	GI	GII	TOTAL	Chronci Bronchitis No. (%)	Bronchial Asthma No. (%)
< 10 Years	105	2 (1.9)	4(3.8)	-	6(5.7)	17(16.2)	2 (1.9)
10 - 20 Years	208	11 (5.3)	6(2.9)	8 (3.8)	25(12)	43(20.7)	12 (5.8)
> 20 Years	282	21(7.4)	14 (5)	34(12.1)	69(24.5)	77(27.3)	50(17.7)
TOTAL	595	34(5.7)	24(4)	42(7.1)	100(16.8)	137 (23)	64(10.8)
					P<0.001	P< 0.05	P< 0.001

Table IV
The Effect of Smoking on the Prevalence of Byssinosis

GROUP	NUMBER EXAMINED	DURATION EXPOSURE (YEARS) (MEAN ± SD)+	BYSSINOSIS NO. (%) G½	GI	GII	TOTAL	CHRONIC BRONCHITIS No. (%)	BRONCHIAL ASTHMA NO. (%)
Smokers	14	17.1 ± 8.2	1 (7.1)	1(7.1)	1(7.1)	3(21.4)*	9(64.3)**	-
Non or Ex-smokers	581	18.2 ± 6.6	33(5.7)	23 (4)	41 (7)	97(16.7)	128 (22)	64 (11)

+N.S.(P> 0.05)   * N.S.   ** P<0.001

(Bahir Dar, 1988)

Table V
Comparison of Cases (Byssinosis and Other Respiratory Tract Diseases Groups) with Control (No Respiratory Tract Disease Group) Using Time Weighted Dust Concentration

GROUP	High Time Weighted Dust Concentration (366.72-1182.72) (mg months/m³) NO.	%	Low Time Weighted Dust Concentration (183.36 -206.4) (mg months/m³) NO.	%	X^2(1d.f.)	P-Value	Odds Ratio	95% Confidence Interval (C.I.)
Control								
. No R.T.D	78	(38.8)	123	(61.2)				
Cases								
. All R.T.D	122	(63.2)	71	(36.8)	23.46	P<0.001	2.71	(2.48, 2.94)
. Byssinosis	69	(93.2)	5	(6.8)	64.41	P<0.001	21.76	(8.41, 56.26)
. Chronic Bronchitis	67	(69.8)	29	(30.2)	24.96	P<0.001	3.64	(2.16, 6.11)
. Bronchial Asthma	29	(78.4)	8	(21.6)	19.79	P<0.001	5.72	(2.48, 13.07)
. Plumonary Tuberculosis	12	(75)	4	(25)	7.99	P<0.01	4.73	(1.46, 15.18)
. Pneumonia	32	(61.5)	20	(38.5)	8.68	P<0.01	2.52	(1.34, 4.71)
. Hay Fever	67	(61.5)	42	(38.5)	14.59	P<0.001	2.52	(1.55, 4.06)

(Bahir Dar, 1988)

Although previous investigators[7,25] found that the prevalence of chronic bronchitis is not related to dust concentrations, the significant relationship observed in our study is in agreement with those of El Karim[2] and Merchant et al.[26] Although cigarette smoking is the single most important etiologic factor of chronic bronchitis, occupational and environmental exposures are now receiving more attention as also supported by our finding.

Our finding also showed that bronchial asthma was high among the blowers and had a significant relationship with the cumulative cotton dust exposure. A majority of the asthmatics developed the problem after they had worked for several years in this textile mill. Even though a majority of the asthmatics gave negative family histories of allergy, 34.4% had had intermittent symptoms of rhinitis which was mostly seasonal.

Our finding showed that there was no significant relationship between hay fever and current dust exposure but the relationship with longevity in the cotton textile mill and cumulative cotton dust exposure was significant. This finding probably might be due to the reason that an allergic reaction does not occur on first exposure. The latent interval during which sensitization occurs varies from a few weeks to many years. When hay fever, for that matter even asthma, first develops some years after an employee entered an industry, it is easy to understand that an occupational origin may be completely overlooked. In our study a majority of hay fever cases developed the symptom complex after many years of longevity in the textile mill.

Even though there is some evidence that byssinosis is not more prevalent among atopic than non-atopic workers,[27] our finding revealed that the majority of byssinotics (55%) had clear-cut characteristic symptom complex of hay fever (allergic rhinitis). Added to this, the prevalence of hay fever was very high in our study population. In agreement to this and as described by Jones et al,[28] atopy might be an important risk factor in the development of byssinosis and indicates the importance of identifying atopic workers.

Our study demonstrated that byssinotics had significantly greater acute decrements in FEV_1 throughout a workshift than those without respiratory tract diseases, supporting the findings of earlier investigators.[9,29,30] The cotton exposed workers with byssinosis had also a significantly lower percent-predicted FEV_1 than those in the group without respiratory tract desease (control), being in agreement with previous investigators.[2,8,9,31,32,33]

In conclusion, our findings suggest that there may be high estimated risk of developing respiratory diseases and impairment as well as leading workers to absence from work due to illness in high time-weighted dust concentration than in low time-weighted dust concentration signifying the extent of the occupational health hazard that calls for due consideration by all those concerned. Also an immunological dysfunction such as atopy, may be a risk factor in the development of cotton dust induced respiratory disease. Thus keeping in mind cotton dust has diverse content as described by many investigators, the extent of association between exposure to cotton dust and hay fever and also the extent of development of byssinosis and other respiratory problems among atopic and non-atopic workers should be investigated and analysed in depth.

Table VI

Comparison of Symptoms of Respiratory Impairment and Period of Absence from Work Due to Sickness in Those Cases with High and Low Time Weighted Dust Concentration with "No Respiratory Tract Disease" Group as Control

GROUP	High Time Weighted Dust Concentration (366.72 - 1182.72) (mg months./ m^3)		Low Time Weighted Dust Concentration (183.36 - 206.4) (mg months/m^3)		X^2(1 d.f.)	P-Value	ODDS Ratio	95% Confidence Interval (C.I.)
	No.	(%)	No.	(%)				
Control								
÷ No R.T.D	78	(38.8)	123	(61.2)				
Cases								
. Sob Hill*	112	(70)	48	(30)	34.77	p<0.001	3.68	(2.36, 5.7)
. Sob Level **	81	(80.2)	20	(19.8)	46.18	p<0.001	6.39	(3.6, 11.25)
. Sob Pace ***	29	(87.9)	4	(12.1)	27. 5	p<0.001	11.43	(6.62, 19.89)
. Sick Week	64	(71.9)	25	(28.1)	27.05	p<0.001	4.04	(2.36, 6.96)
. More Illness	32	(69.6)	14	(30.4)	13.77	p<0.001	3. 6	(1.8, 7.17)

(bahir Dar, 1988)

* Shortness of breath while walking up a slight hill

** Shortness of breath while walking on a level ground with persons of the same age

*** Shortness of breath even when walking at own pace.

Table VII
Chronic Changes in FEV_1 among Exposed Workers

Byssinosis	Number Examined	FEV_1 CHRONIC CHANGES *					
		No. Change > 80% of Predicted Value		Moderate 60-80% of Predited Value		Severe < 60% of Predicted Value.	
		No.	%	No.	%	No.	%
No. R.T.D Controls	309(51.93)	210	67.96	96	31.07	3	.97
Byssinosis							
Grade ½	34(5.71)	20	58.82	13	38.24	1	2.94
Grade 1	24(4.03)	11	45.83	8	33.33	5	20.83
Grade II	42(7.06)	9	21.43	15	35.71	18	42.86
All Grades	100(16.81)	40	40	36	36	24	24**
Total	595(100)	376	63.19	191	32.1	28	4.71

Lung function was not recorded for 32 subjects.

* Graded according to Bouhuys et al. (1970)

** $P < 0.001$

(Bahir Dar, 1988)

Table VIII

Regression Coefficients for Time Weighted Cotton Dust Concentration, Age, Height and Weight in Byssinosis and Pulmonary Function Models

	VARIABLE	MALE (N = 323)	FEMALE (n= 272)	ALL WORKERS (N = 597)
Byssinosis*	Total Dust	$0.002^{\pm}$	$0.002^{\pm}$	$0.002^{\pm}$
	Age	0.059	0.104*	0.079
	Weight	-0.012^{+}	-0.109*	-0.01^{+}
	Height	-0.01	0.002	0.033
FEV_1**	Total Dust	$0.221^{\pm}$	$0.167^{\pm}$	$0.207^{\pm}$
	Age	0.095	0.009	0.06
	Weight	-0.07	-0.017	- 0.045
	Height	-0.018	-0.044	- 0.011
FVC***	Total Dust	$0.085^{\pm}$	$0.044^{\pm}$	$0.061^{\pm}$
	Age	0.115	0.015	1.088^{+}
	Weight	-1.029+	0.033	- 0.019
	Height	0.039	0.072	0.048

Lung function was not recorded for 32 subjects.

± $p < 0.001$

\+ $p < 0.05$

N.B. For differences between sexes, after allowance for age, height and weight.

*MALE F (1 and 320 d.f.) = 98.96 P<0.000 and R^2 =0.23621
*FEMALE F(1 and 271 d.f.) =44.96 P<0.000 and R^2 =0.14229
** MALE F (1 and 302 d.f.) =52.53 P<0.000 and R^2=0.14100
** FEMALE F (1 and 257 d.f) =17.2 P<0.0000 and R^2=0.05967
*** MALE F (1 and 302 d.f.) =22.14 P<0.000 and R^2=0.06471
*** FEMALE F(1 and 257 d.f.) = 4.05 P<0.0452 and R^2=0.01472

(Bahir Dar, 1988)

Table IX

Regression Coefficients for Period of Exposure, Current Cotton Dust Exposure and Cumulative Cotton Dust Exposure in Byssinosis, Chronic Bronchitis, Bronchial Asthma, Pulmonary Tuberculosis, Pneumonia, Hay Fever and Pulmonary Function Models

Symptom	Period of Exposure (Months)	Current Exposure Cotton Dust Concentration (mg/m^3)	Cumulative Exposure Cotton Dust Concentration ($mg\ months/m^3$)
Byssinosis	0.002#	0.308#	0.001#
Chronic Bronchitis	0.042**	0.065	3.76 E-04#
Bronchial Asthma	0.066*	0.117	0.075**
Pulmonary Tuberculosis	8.65 E-04	0.011	7.26 E-05*
Pneumonia	0.046	0.055	1.84 E-04+
Hay Fever	7.14 E-04+	0.066	0.077**
FEV_1	0.427	0.054	0.154##
FVC	0.005	0.006	0.06#

\# P< 0.001

\+ P< 0.01

* P< 0.05

** P< 0.05 in one tail test (this is considered since the hypothesis from the outset was unindirectional)

N.B. General Models: $\text{Symptom} = \beta_0 + \beta_1 (\text{age}) + \beta_2 (\text{Sex}) + \beta_3 (\text{height}) + \beta_4 (\text{weight}) + \beta_5 (\text{exposure}) \times \epsilon$

(Bahir Dar 1988)

REFERENCES

1. El. Batawi, M.A.: Byssinosis in the Cotton Industry in Egypt. *Br. J. Ind. Med.* 19:126-130 (1962).
2. Awad El Karim, M.A., Osman, Y., El Haimi, Y.A.: Byssinosis: Environmental and Respiratory Symptoms Among Textile Workers in Sudan. *Int. Arch. Occup: Environ. Health.* 57:101-108 (1986).
3. Mustafa, K.Y.: Byssinosis in Tanzanian Textile Workers. *Lung* 159:39-44 (1969).
4. Morgan, P.G.M., Ong, S.G.: First Report of Byssinosis in Hong Kong. *Br. J. Ind. Med.* 38:290-292 (1981).
5. Schilling, R.S.F.: Byssinosis in Cotton & other Textile workers. *Lancet.* 2:261-265 (1956).
6. Molyneux, M.K.B., Tombleson, J.B.L.: An Epidemiological Study of Respiratory Symptoms in Lancashire Mills, 1963-1966. *Br. J. Ind. Med.* 27:225-234 (1970).
7. Berry, G., Molyneux, M.K.B., Tombleson, J.B.L.: Relationship between Dust Level & Byssinosis & Bronchitis in Lancashire Cotton Mills. *Br. J. Ind. Med.* 31:18-27 (1974).
8. Schilling, R.S.F.: Epidemiological Studies of Chronic Respiratory Diseases Among Cotton Operatives. *J. Biol. Med.* 37:55-74 (1964).
9. Berry, G., McKerrow, C.B., Rossiter, C.E., Tombleson, J.B.L.: A study of Acute and Chronic Changes in Ventilatory Capacity in Workers in Lancashire Cotton Mills. *Br. J. Ind. Med.* 30:25-36 (1973).
10. Bouhuys, A., Schoenberg, J.B., Beck, G.J., Schilling, R.S.F.: Epidemiology of Chronic Lung Disease in a Cotton Mill Community. *Lung.* 154:167-186 (1977).
11. Mair, A., Smith, D.A., Wilson, W.A., Lockhart, W.: Dust Diseases in the Dundee Textile Workers. *Br. J. Ind. Med.* 17:272-278 (1960).
12. Wolde, Yohannes M.: *Health Profile & Plan of Action for Bahir Dar Awraja.* Ministry of Health, Educational Health Service Report. Addis Ababa (1987).
13. Schilling, R.S.F., Vigliani, E.C., Lammers, B., Valic, F., Gilson, J.C.: A Report on a Conference on Byssinosis. (14th International Conference on Occupational Health, Madrid, 1963). *Excrepta. Media.* 2:137-145 (1964).
14. Fletcher, C.M.: Chronic Bronchitis. *Am. Rev. Respir. Dis.* 80:483-484 (1959).
15. Hinshaw, H.D., Garland, L.H.: *"Diseases of the Chest.* 2nd Ed. pp 299. W.B. Saunders Co., Philadelphia (1963).
16. Isselbacher, K.J., Adams, R.D., Braunwald, E., Petersdorf, R.G., Welson, J.D.: *Harrison's Principles of Internal Medicine.* 11th Ed. pp 1412-1414. McGraw-Hill Inc. Hamburg (1987).
17. Cherniack, R.M., Rater, M.B.: Normal Standards for Ventilation Function Using an Automated Wedge Spirometer. *Am. Rev. Respir. Dis.* 106:38-46 (1972).
18. Bouhuys, A., Gilson, J.C., Schilling, R.S.F.: Byssinosis in the Textile Industry. *Arch. Environ. Health.* 21:475-478 (1970).
19. *American Conference of Government Industrial Hygienists.* Threshold Limit Values, AGGIH, Cincinnati, Ohio (1983).
20. Awad El Karim, M.A., El Hag, A.A.: Byssinosis and Tuberculosis in Cotton Industry in Sudan. *East. Afr. Med. J.* 62:491-500 (1985).
21. Noweir, M.H., Noweir, K.H., Ossman, H.A., Moseillin, M.: An Environmental & Medical Study of Byssinosis and other Respiratory conditions in the Cotton Textile Industry in Egypt. *Am. J. Ind. Med.* 6:173-183 (1984).
22. Holness, D.L., Taraschuk, L.G., Pelmear, P.L.: Effect of Dust Exposure in Ontario Cotton Textile Mills. *J. Occup-Med.* 25:26-69 (1983).
23. Ong, S.G., Jam, T.H., Wong, C.M., Ma, P.L., Lam, S.K., O'Kelly, E.J.: Byssinosis in Hong Kong. *Br. J. Ind. Med.* 42:499-52 (1985).
24. Parikh, J.R., Chatterjee, B.B., Rao, N.M., Bahgia, L.J.: *The Clinical Manifestations of Byssinosis in Indian Textile Workers.* NIOH (National Institute of Occupational Health.) pp. 24-28. Ahmedabad, India.
25. Fox, A.J., Tombleson, J.B.L., Watt, A., Wilkie, A.G.: A Survey of Respiratory Disease in Cotton Operatives. Part II Symptoms, Dust Estimations & the Effect of Smoking Habit. *Br. J. Ind. Med.* 30:48-53 (1973).
26. Merchant, J.A., Lumsden, J.C., Kilburn, K.H., O'Fallon, W.M., Ujda, J.R., Germino, V.H., Hamilton, J.D.: An Industrial Study of the Biological Effects of Cotton Dust & Cigarette Smoke Exposure. *J. Occup. Med.* 15:212-221 (1973).
27. Bouhuys, A.: Asthma & Byssinosis. *Rev. Allergy.* 22:473-476 (1966).
28. Jones, R.N., Butcher, B.T., Hammand, Y.Y., Diem, J.E., Glindmeyer, H.W. III, Jehrer, S.B., Hughes, J.M., Weill, H.: Interaction of Atopy & Exposure to Cotton Dust in the Bronchoconstrictor Response. *Br. J. Ind. Med.* 37:141-146 (1980).
29. McKerron, C.B., McDermoth, M., Gelson, J.C., Schilling, R.S.F.: Respiratory Function During the Day in Cotton Workers: A Study in Byssinosis. *Br. J. Ind. Med.* 15:75-83 (1958).
30. Buck, M., Bouhuys, A.: A Purified Extract from Cotton Bracts Induces Airway Constriction in Humans. *Chest.* 79:43-49 (1981).
31. Beck, G.J., Schachter, E.N.: The Evidence for Chronic Lung Disease in Cotton Textile Workers. *Am. Stat.* 37:404-412 (1983).
32. Schachter, E.N., Maunder, L.R., Beck, G.J.: The Pattern of Lung Function Abnormalities in Cotton Textile Workers. *Am. Rev. Respir. Dis.* 124:523-527 (1984).
33. Beck, G.J., Schachter, E.N., Maunder, L., Schilling. R.S.F.: A Prospective Study of Chronic Lung Disease in Cotton Textile Workers. *Am. Int. Med.* 97:645-651 (1982).

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RESPIRATORY SYMPTOMS AND DUST EXPOSURE IN THE WOOL TEXTILE INDUSTRY

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Previous studies have indicated that respiratory symptoms are more prevalent in workers exposed to wool mill dust than in those who are not[1,2,4,5,7,9] but only one study of respiratory symptoms in wool textile workers in the United Kingdom has been reported.[1]

Moll[6] first identified cases of occupational asthma among workers exposed to wool in 1933 but more recent studies have reported non-specific symptoms of chronic bronchitis and shortness of breath as the main respiratory condition experienced by between 5% and 50% of the workforce depending on age and length of exposure.[2,4,5] Other studies of wool textile workers have also indicated a fall of lung function during a work shift[9] or on the first day back at work.[7] Bacterial endotoxin has been implicated as the aetiological agent in the most recent study.[7]

We have undertaken an epidemiological survey of over two thousand workers in the woollen, worsted and carpet yarn sectors of the industry and have compared the frequencies of respiratory symptoms reported by these workers with measured concentrations of inspirable wool mill dust in their immediate vicinity by means of personal dust sampling.

METHODS

Fifteen wool textile mills employing 2783 workers in and around Bradford, Dewsbury and Hudderfield in West Yorkshire were selected to participate in the study. They represented all the main processes which are carried out in the industry, and ranged in size from 4 to nearly 400 employees. We designed a respiratory symptoms questionnaire intended to establish a broad range of symptoms and their possible temporal and locational relationships to occupation and current dust exposure. Questions about cough, phlegm, wheezing, chest tightness, breathlessness and its variability, rhinitis, conjunctivitis, nosebleeds, chills and chest illnesses were included, some of these qualified by additional questions identifying exacerbation or improvement of symptoms at different times of day, days of the week, seasons and in particular places. Detailed smoking histories and occupational histories including details of shifts and part-time work were also obtained from which jobs could be allocated to occupational groups. These questionnaires were translated into Urdu for use on Asian workers who did not speak fluent English.

Concentrations of inspirable dust were measured using Institute of Occupational Medicine personal inspirable dust samplers, which were worn for part or all of a shift by representative workers in each job or process, a larger number of samples being collected in the dustier jobs. Average inspirable dust concentrations were assigned to each of 16 occupational groups, based on the measurements made at the mill concerned or estimates derived from log-linear models from the measurements made elsewhere. Endotoxin levels in dust were also measured in a limited number of static samples at six mills by the Limulus method.[8] These measurements were performed under the direction of Dr. M.D. Topping, Occupational Medicine and Hygiene Laboratory, Health and Safety Executive).

Logistic regression analyses were used to assess the contribution of independent variables such as dust concentration to explain the variation in each of the symptoms separately.

RESULTS

Inspirable dust concentrations based on 630 personal samples ranged from zero in non-process work to over 100 mg/m^3 in some very dusty processes, such as work with wool waste. Over 9% of the workforce were exposed to shift average dust levels greater than 10 mg/m^3, the nuisance dust standard currently applied to the industry. Wool opening, blending, worsted carding and carpet yarn backwinding were particularly dusty jobs, average levels being as high as 14.8, 180.5, 39.1, and 46.7 mg/m^3 respectively in some mills. Endotoxin was found in measurable quantities (up to 650 ng/mg dust) in several samples throughout the process.

Complete questionnaire data were available for 2151 workers, which represents 85% of the available workforce. Of these workers 77% were male, 69% European, 28% Asian and 3% West Indian in origin. Just under half were current smokers. Eighteen percent opted to be interviewed in Urdu.

Symptom prevalences in the population overall were as follows: Chronic bronchitis (persistent cough and phlegm), 9%; wheeze (at any time), 31%; breathlessness grade 3 (walking with others on level ground), 10%; persistent rhinitis, conjunctivitis and chills, 18%, 10% and 2% respectively and 10 or more nosebleeds in the past year, 2%. The first five of these symptoms were significantly related to current dust concentration once age, sex, smoking habit and ethnic group had been allowed for. Table I shows the prevalence of these symptoms at increasing inspirable dust levels.

The results of the logistic regression analysis predicted a rapid rise in symptom prevalences over the dust concentration range

0-5 mg/m^3 and a slower increase at higher concentrations up to 20 mg/m^3 and above (Table II). The highest relative risks in non-smokers for some of the more important symptoms were found among European women and were, in relation to non-dust exposed, non-smoking women aged 40, 2.47 for rhinitis, 2.77 for chronic bronchitis, 3.56 for conjunctivitis and 6.20 for grade 3 breathlessness at concentrations of 10 mg/m^3.

In addition, the risk of taking time off work because of chest illnesses increased significantly with increasing dust exposure, and dyers and scourers had a four-fold higher risk despite low dust exposures.

DISCUSSION

This study was designed to include the full range of working conditions to be found in the British wool textile industry. The entire workforce of 15 mills was encouraged to participate and the overall response rate of 85% gives confidence that the results are reasonably representative of the whole current workforce. The specially designed questionnaire was intended to identify all the common respiratory symptoms, in order to assess the syndromes related to wool dust exposure. Inclusion of material from other tried and tested questionnaires; thorough testing for comprehensibility and ease of use; and the similar relations of symptoms and smoking habit among

Table I
Symptom Prevalences in Groups Exposed to Different Dust Levels

		Dust concentration (mg/m^3)				
Symptom	Grade	<0.1 (4)*	0.1-1 (1206)	1-10 (740)	10-100 (187)	>100 (6)
Cough and Phlegm	Occasional	25	19.6	25.2	37.4	50
	Persistent	0	5.8	10.8	19.8	33.3
Wheeze	Present	50	24.6	35.3	55.1	66.7
Breathlessness	2 and 3	25	39.3	40.8	60.4	50
	4 and 5	0	1.8	3.0	1.6	0
Rhinitis	Occasional	25	15.7	19.7	29.4	0
	Persistent	0	14.9	19.3	36.9	16.7
Conjunctivitis	Occasional	25	11.3	12.6	23.0	33.3
	Persistent	0	8.0	10.0	23.0	50

* Number of individuals in group

Table II
Estimated Frequencies* of Symptoms, Predicted for Different Inspirable Dust Concentrations in Current Job

Estimated symptom frequency (%)	Dust concentration (mg/m^3) 0	2.5	5	10	20
Persistent cough and phlegm	5	9	11	12.5	14.5
Breathlessness, grade 3 or more	6	10.5	13	14	14.5
Persistent rhinitis	12	18	20	22	23
Persistent conjunctivitis	6	10	11.5	13.5	16.5

* weighted averages of estimated frequencies for non-smokers and current smokers aged 40, assuming a population including proportions of smokers, non-smokers, men, women, ages and ethnic groups similar to the population under study.

different ethnic groups and Urdu speakers also encourages us to have confidence in the results of this questionnaire. Furthermore the consistency of the results across all factories and other subgroups of the workforce, and consistency between symptom complexes, is strong evidence that the associations between symptoms and inspirable dust concentrations are real. We selected the inspirable fraction, which includes the respirable fraction, because of our concern with health effects on the nose as well as the lungs.

Our results confirm previous reports of respiratory symptoms related to exposure to dust or length of time spent working in wool textile mills.[1,2,4,5,7,9] We also identified the presence of endotoxin in a limited series of measurements and further studies are currently being undertaken to investigate the possible role of endotoxin in the causation of respiratory disease among wool textile workers. Indeed a recent study has implicated bacterial endotoxin in the aetiology of a byssinotic-like condition among Turkish carpet weavers.[7]

The questionnaire responses indicate dust related disease at all levels of the respiratory tract, although it is not clear whether the pathogenesis of this response includes pharmacological, toxic or allergic mechanisms, or is merely a response to the physical dust load.

Evidence (not presented here) from exploratory questions on the variability of breathlessness suggests that, although related to dust exposure, such symptoms are relatively infrequent, about 3% overall. Therefore these symptoms are in most cases not very like asthma but require further investigation as does the observation of increased risk of time off work because of chest illnesses amongst workers involved in the scouring (hot, usually alkaline, washing) and dyeing of wool. The latter process has been shown to be associated with increased respiratory and nasal symptoms of either an irritant or a specific allergic nature.[3] Positive responses to questions about chills (shivering or feverishness), an attempt to identify symptoms of humidifier fever, were unduly frequent in some occupational groups but did not, as expected, show any relation with exposure to dust.

The functional and prognostic implications of wool dust related symptoms are not yet known. However, recent studies undertaken by us suggest that dust related functional impairment does occur, slight but significant reductions of FEV_1 and FVC being observed among Asian men and reduced FEV_1/FVC ratio among European women. An additional loss of FEV_1 among dyers and scourers (unrelated to dust exposure) is consistent with the observations on respiratory illnesses made by ourselves and others.[3] Other investigations currently being pursued suggest that inflammatory and non-specific immunological responses can be caused in rodent models by inspirable wool mill dust and we intend to report on these shortly.

Meanwhile, we can conclude that exposure to wool mill dust appears to be related to symptoms, when exposure is within "nuisance dust" limits of 10 mg/m^3. At this concentration the overall estimated risks of symptoms relative to unexposed workers are: chronic bronchitis, 1.37; wheeze, 1.40; breathlessness grade 3 or more, 1.48; persistent rhinitis, 1.24; and persistent conjunctivitis, 1.70. The relative risk of these symptoms increases rapidly up to 5mg/m^3 and more slowly thereafter. The results of these studies and further investigations into the functional and other characteristics of respiratory conditions among wool textile workers, should be helpful in making decisions on an airborne dust standard for the wool textile industry.

REFERENCES

1. Allardice, J.T., Clarke, E.C., Jones, R.D.: A study of the prevalence of epistaxis and respiratory symptoms in carpet backwinders. *J. Soc. Occup. Med.* 33:36-41 (1983).
2. Brysiewicz, K., Buluk, H., Cesar-Fronczyk, M., Korkecha, J., Leszczynski, B., Lukjan, K., Sadokierska, H.: The effect of work in dusty surroundings on the prevalence of chronic bronchitis among the workmen of Sierzon's establishments of the wool industry at Bialystok. *Gruzlica* 38:657-661 (1970).
3. Docker, A., Wattie, J.M., Topping, M.D., Luczynka, C.M., Newman-Taylor, A.J., Pickering, C.A.C., Thomas, P., Gompertz D.: Clinical and immunological investigations of respiratory disease in workers using reactive dyes. *Br. J. Ind. Med.* 44:534-541 (1987).
4. Jordeczka, S., Basa, S., Basa B.: Prevalence of chronic non-specific bronchopulmonary disease in wool industry workmen. *Gruzlica* 38:643-650 (1970).
5. Mathur, K.C., Misra, S.N.: Incidence of pulmonary disease among wool workers. *Indian J. Chest Dis.* 14:172-178 (1972).
6. Moll, H.H.: Occupational asthma with reference to wool sensitivity. *Lancet* 1:1340-1342 (1933).
7. Ozesmi, M., Aslan, H., Hillerdal, G., Rylander, R., Ozesmi, C. Baris, Y.I.: Byssinosis in carpet weavers exposed to wool contaminated with endotoxin. *Br. J. Ind. Med.* 44:479-483 (1987).
8. Rylander, R., Haglind, P., Lundholm, M: Endotoxin in cotton dust and respiratory function decrement among cotton workers in an experimental cardroom. *Am. Rev. Resp. Dis.* 131:209-213 (1985).
9. Zuskin, J.H., Valic, F., Bouhuys, A.: Effect of wool dust on respiratory function. *Am. Rev. Resp. Dis.* 114:705-709 (1976).

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