Arh. hig. rada toksikol., **30** *(1979) suppl. pp. 903–910.*

RESPIRATORY SYMPTOMS AND CHANGES OF PULMONARY FUNCTION ASSOCIATED WITH RADIOGRAPHIC EVIDENCE OF ANTIMONY OXIDE DUST RETENTION

G. L. LEATHART

Department of Occupational Health and Hygiene, University of Newcastle upon Tyne, Newcastle upon Tyne, United Kingdom

ABSTRACT

All 354 workers at a plant producing antimony oxide were radiographed and investigated. Exposure to antimony oxide dust caused X-ray evidence of dust retention in 16.4% of current employees, usually after 10 years. Men with dust retention had slight, but significant, reduction of pulmonary function. "Bronchitis" and dyspnoea reached significance only in men who had dust retention and also smoked cigarettes.

Review after four years revealed that more office staff complained of dyspnoea and more plant workers had reduced their smoking. Deterioration of FEV and FVC was a prominent feature of maintenance workers.

Men who work in a factory making pure antimony oxide from crude antimonious ores are known to develop dust opacities in the lungs[3]. There are usually no clinical signs accompanying this condition. Little is known about the prevalence of this abnormality nor whether it is accompanied by respiratory symptoms or functional abnormality. The investigation described here was designed to elucidate these points.

SUBJECTS AND METHODS

Chest radiographs (National Coal Board Radiological Service) of the total workforce present during one particular week were obtained. Later these employees answered the Medical Research Council Questionnaire on Respiratory Symptoms (1966) and measurements were made of the forced expiratory volume in one second (FEV_1) and of the forced vital capacity (FVC) with a dry wedge-spirometer (Vitalograph). Each employee was encouraged to make several recordings until three tracings showed close agreement. The readings (taken at sea level) were converted to 37 °C saturated with water vapour at ambient barometric pressure and compared with nomograms predicting the normal value[1]. Seventy men were selected for measurement of transfer factor by the

singlebreath method with a Morgan Respirameter. These 70 men consisted of two complete shifts of antimony process-workers, a number of other men who were selected on the basis of having a chest radiograph showing dust retention, and a number of laboratory and office staff who had no occupational exposure to antimony dust or to other fumes on the factory floor. In order to allow for differences in age and body size, all results were expressed as a percentage of predicted values.

Because it was felt unlikely that exposure to dust and fumes on the factory floor would have any demonstrable effect in less then 6 months, the results obtained from all those men who had been employed for less than 6 months were set on one side, and the results obtained in female employees (secretaries, cleaners, cooks, canteen staff) were not considered any further. This left 45 men employed in the offices and laboratories and 200 antimony oxide plant workers. Of these, 17 were discarded for a number of reasons (some had left before the questionnaire could be completed, some had refused to undergo measurements of lung function and one was known to have partial collapse of a lung due to carcinoma of the bronchus). There were, thus, 200 in whom the chest radiograph could be analysed, and 183 in whom questionnaire and function tests were completed.

The chest radiographs were viewed by two readers, very familiar with reading films for pneumoconiosis and were assessed, using standard films (I. L. O.) for comparison, according to the I. L. O. classification (1970). The few discrepancies between the two readers were decided by joint review of the films.

RESULTS

Radiology

The chest radiographs might have been influenced by the previous employment of some of the men. Thus 47 radiographs were classified into Category 2 or 3, but 17 of these were from men who had had some exposure to dust (usually coal or zircon) in previous jobs. Two had had under 2 years exposure to antimony. The distribution of radiological abnormality among the remaining 30 men is depicted in Figure 1. In this figure the radiographs in Category 1 have been grouped with those which were assessed as Category 0 because the reading of Category 1 is so dependent on radiological technique. The first definite (Category 2 or 3) radiological abnormalities appeared 4 years after the start of employment but did not affect a substantial proportion of the workforce until more than 10 years had passed. The radiological abnormalities were usually punctiform micronodular shadows occasionally accompanied or supplanted by fine linear shadows. Their prevalence was 30 from a population of 183 (i. e. 16.4%).

Symptoms

The MRC Questionnaire enables one to identify subjects who admit to having cough and phlegm (sputum) for at least 3 months in the year, and to distinguish a group who complain of shortness of breath when hurrying on level

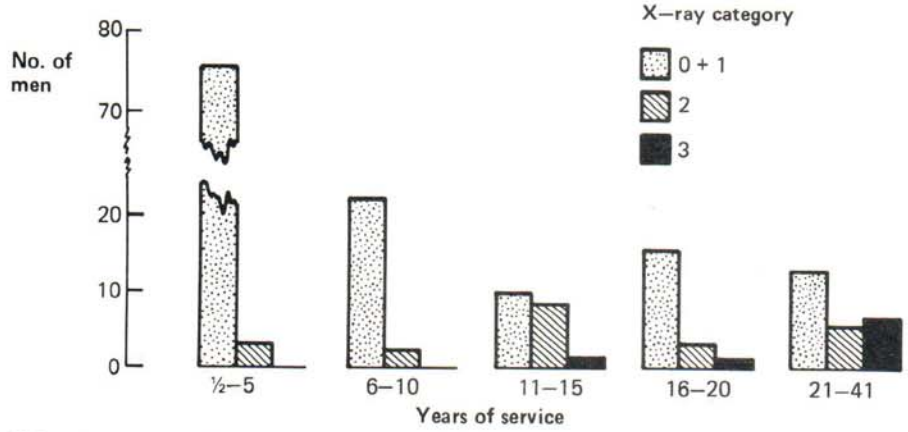

FIG. 1 – The number of men in each radiological category is plotted against years of employment at the antimony plant (but excluding men in Categories 2 and 3 who had previous exposure to other mineral dust).

ground or walking up a slight hill. Many subjects fall into both groups and many of them reveal that they have frequently been diagnosed as bronchitics in the past. For the sake of brevity those with cough and phlegm are referred to as having "bronchitis", although bronchitis defined in this way does not correspond to "chronic bronchitis" as defined in many previous publications. It identifies a group with productive cough, a group which Gandevia and Milne[2] regard as being particularly sensitive to the effects of inhaled industrial dust.

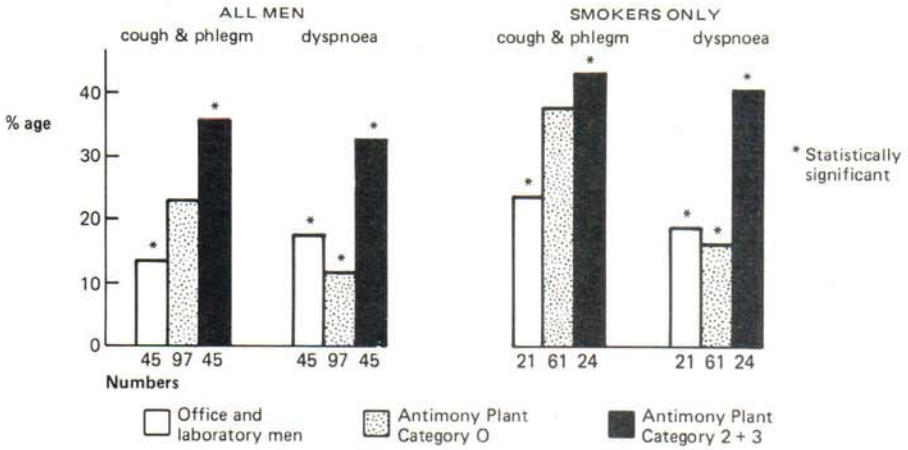

FIG. 2 – The percentage of men with symptoms. Antimony plant workers with dust retention (Categories 2 and 3) are compared with office and laboratory staff and with men exposed to dust but showing no dust retention. The asterisk indicates a proportion of workers which differs significantly from the men with dust retention.

Respiratory symptoms might be due to dust retention visible on the radiograph, might be due to exposure to other respiratory irritants in the factory, and are certain to have been influenced by smoking cigarettes. An effort was made to take all these factors into account, firstly by comparing factory workers showing dust retention with factory workers showing no dust retention, secondly by comparing factory workers with office and laboratory staff, and thirdly by comparing smokers or non-smokers in one of these groups with smokers or non-smokers in the other. It was found that "bronchitis" and dyspnoea are commoner in men who show dust retention than in men not exposed to dust at all (Fig. 2). Among the men exposed to dust dyspnoea is more common in those who show dust retention but bronchitis is not significantly more common. These findings were limited to smokers; both bronchitis and shortness of breath were so seldom encountered among non-smokers (in only 9 out of 59) that no meaningful analysis could be done. Thus work in the antimony plant is not significantly associated with either "bronchitis" or dyspnoea except in men who both smoke and show dust retention.

Physiological tests

Figure 3 depicts the FEV as a percentage of predicted normal in various radiological categories. The mean and standard deviation of each group are given. There was no difference between the men in Category 0, whether they were smokers, non-smokers, had worked for over 6 months, or under 6 months, and they did not differ from office staff. Men in Category 1 did not differ significantly from those in Category 0, but men showing radiological opacities amounting to Categories 2 and 3 gave significantly lower results. The mean

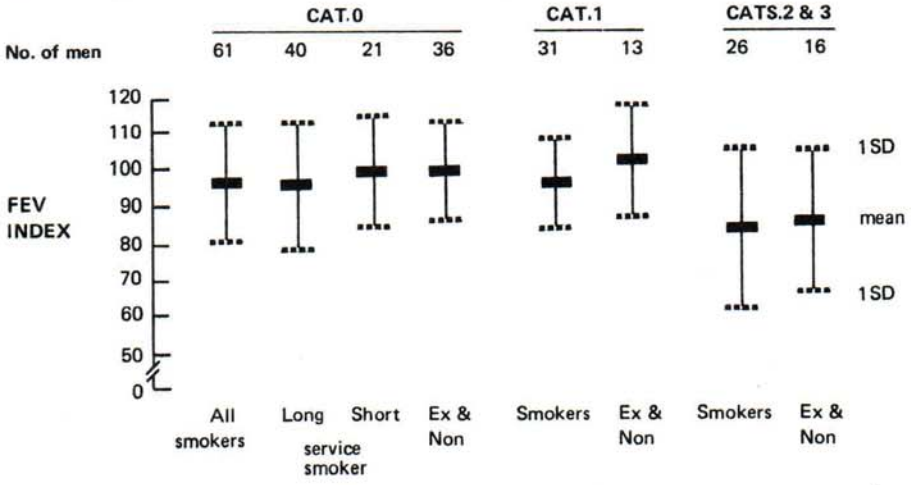

FIG. 3–Forced expiratory volume as a percentage of predicted normal value in men exposed to antimony dust. Mean and standard deviation in different radiological categories and different smoking categories. The long service men are those who have been employed for more than 6 months, the short service men for less than 6 months.

result was, however, not far from the predicted value being 84% in smokers and 86.3% in non-smokers and ex-smokers.

The mean FVC as a percentage of normal was significantly lower in Categories 2 and 3, (in both smokers and non-smokers) than in men in Category 0 (Fig. 4). There was no difference between men in Category 0, Category 1, and either office and laboratory staff or men with less than 6 months service. The average FVC in Categories 2 and 3 was 94% in smokers and 91% in men who were not smoking.

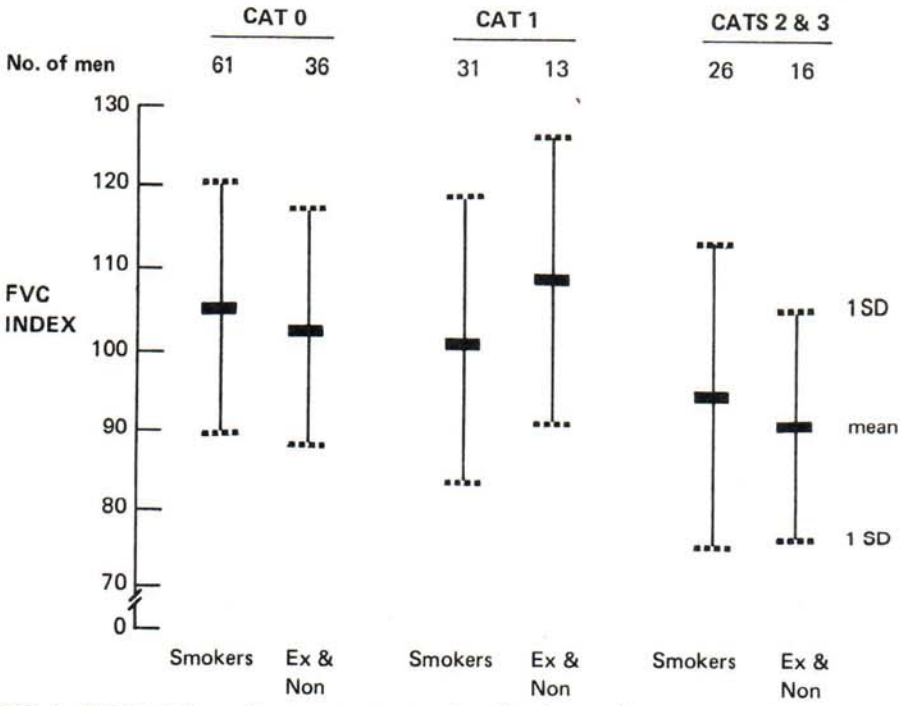

FIG. 4—Forced vital capacity as a percentage of predicted normal in men exposed to antimony dust. Mean and standard deviation in different radiological and smoking categories.

The physiological abnormalities in men in Categories 2 and 3 could not be attributed to their age or length of service (with which the physiological results showed no significant association). They were not due to exposure to dusts in previous jobs because the same changes were demonstrable in men who had never been exposed to any other mineral dust. The FVC in these men with "pure" exposure to antimony is shown in Figure 5 (though it was only in non-smokers that the mean was low enough to reach statistical significance). The mean FEV of these men was significantly less than that of men in Category 0 whether they were currently smoking (FEV = 81%) or not smoking (FEV = 82%).

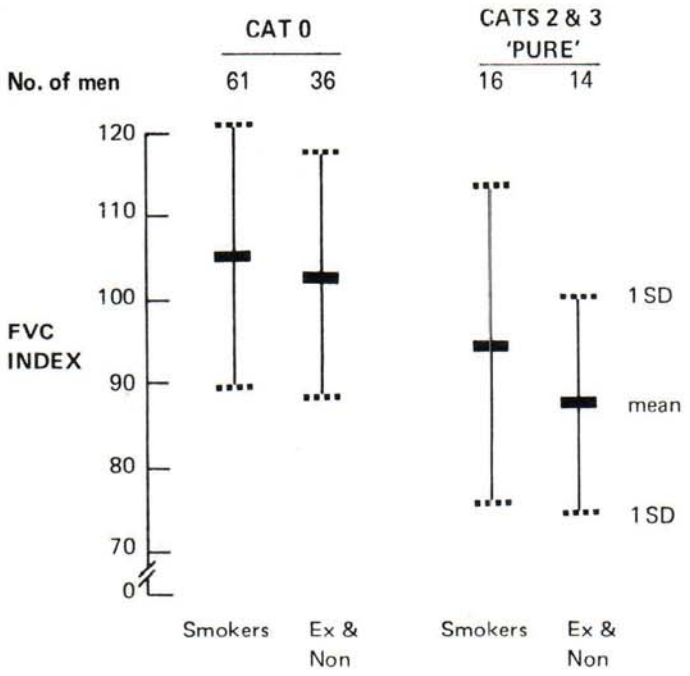

FIG. 5 – The forced vital capacity as a percentage of predicted normal in men exposed to antimony dust, excluding from Categories 2 and 3 those men who had previous exposure to other dusts.

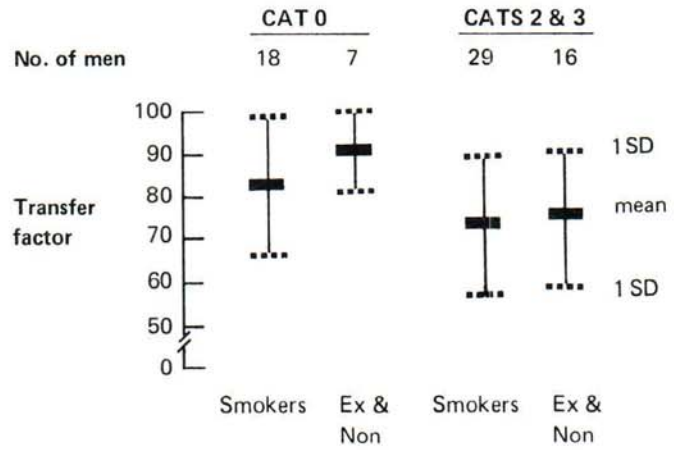

FIG. 6 – Transfer factor in 70 selected men exposed to antimony dust, expressed as a percentage of predicted normal. Mean and standard deviation in different radiological and smoking categories.

Figure 6 depicts the average transfer factor in 70 selected men. It was only in men who were not smoking that there was a significantly reduced transfer factor associated with dust retention.

Thus it appears that retention of antimony oxide dust is associated with reduction of FEV and FVC and possibly of transfer factor. The reductions are small and, suprisingly, do not show a significant positive association with the symptom of dyspnoea.

Reinvestigation after 4 years

One hundred and nineteen of the original 183 plant workers and 21 of the original office and laboratory staff were available for review. Subjective symptoms based on the answers to the Questionnaire in these two groups are tabulated in Table 1. In both groups some men have apparently got better and some have got worse. If the answers given to a Questionnaire can be taken at face value then 64 of the plant workers have an alteration in their symptoms, 34 being worse and 30 being better. Roughly the same proportion of the staff (12 out of 21) now claim to have more severe symptoms, but only 4 out of 21 assess their symptoms as improved. The only significant differences between staff and plant workers are the high proportion of staff now admitting to dyspnoea and the high proportion of plant workers who are smoking less (or have stopped smoking altogether). Fourteen of the 17 plant workers with less cough were smoking less, and so were five of the eight with less phlegm.

TABLE 1
Results of the reinvestigation after 4 years.

Symptoms		Plant workers (119)		Office and laboratory (21)	
		No.	% of men	No.	% of men
Subjective (questionnaire)	More cough	6	5.0	2	9.5
	More phlegm	7	5.9	1	4.8
	More C+P ('bronchitis')	8(4new)	6.7	3(1new)	14.3
	More breathless	13	10.9	6	28.6
	Smoking more	8	6.7	2	9.5
	Less cough	17	14.3	3	14.3
	Less phlegm	8	6.7	0	0
	Less 'bronchitis'	4	3.4	1	4.8
	Less breathless	1	0.8	0	0
	Smoking less	45	39	1	4.8
Objective tests (vitalograph)	FEV down >10%	21 −4)	17.7*	3(−1)	14.3
	FVC down >10%	20 −4)	16.8**	1	4.8
	FEV up >10%	0		0	
	FVC up >10%	0		2	9.5

*Process workers FEV down > 10% = 10.9%; maintenance workers down > 10% = 21.9%
**Process workers FVC down > 10% = 12.7%; maintenance workers down > 10% = 20.2%
Figures underlined are the only significant differences (χ^2 test) between plant workers and staff. There were no subjective differences between process and maintenance workers symptoms.

Objective changes in FEV and FVC exceeding 10% of the original measurement are displayed in Table 1. There were 21 plant workers showing a reduction but in four of them the result was still above the predicted normal, and 20 gave a lower result for the FVC. The proportion of workers so affected was the same in the office and laboratory staff. However, if the plant workers are split into process operators (55 in number) and maintenance workers (64 in number) there is a significant excess of maintenance workers who show reduction of FEV and FVC exceeding 10% in the course of 4 years. Subjective symptoms in these two groups, however, showed no significant difference.

The precise implications of this observation have yet to be determined. It must be appreciated that men who are finding the process work too hard are transferred to maintenance and one would therefore expect more deterioration among the maintenance workers. On the other hand the earlier part of this paper demonstrates that loss of ventilatory function was associated with dust retention, and, if one assumes that dust retention is greatest in those who have the greatest dust exposure, this suggests that maintenance workers may now have greater exposure to dust than process workers.

The concentrations of respirable antimony oxide dust in air mg/m^3 in one part of the factory at furnaces over the course of years was as follows: 1957 = 4, 1963 = 5, 1970 = 6, 1972 = 2. In 1974 and 1978 the concentrations in personal samples were 1.5 and 0.9 mg/m^3 respectively. It can be seen that dust suppression has had a great impact on the exposure of process-workers. Perhaps it has had less effect on the exposure of maintenance men.

ACKNOWLEDGEMENTS

The author expresses his gratitude for the help of Sister P. Jeffrey and Sister I. A. Dodd, without whom the surveys could not have been completed.

REFERENCES

1. *Cotes, J.E.* Lung Function Assessment and Application in Medicine. Blackwell Scientific Publications, Oxford, 1968.
2. *Gandevia, B. and Milne, J.* Occupational asthma and rhinitis due to western red cedar *(Thuja plicata)* with special reference to bronchial reactivity. Br. J. Ind. Med., **27** (1970) 235–244.
3. *McCallum, R.I.* The Work of an Occupational Hygiene Service in Environmental Control. Ann. Occup. Hyg., **6** (1963) 55–64.