VALUE OF SCREENING SPIROMETRY IN EPIDEMIOLOGIC STUDIES OF PNEUMOCONIOSIS

G. W. FRANK,* M.D. • P. Harber†

*Department of Medicine, Veterans Administration Medical Center, Los Angeles, California, USA
†Occupational Medicine Branch, Pulmonary Division, Department of Medicine, University of California, Los Angeles, California, USA

ABSTRACT

Pneumoconioses typically cause a restrictive ventilatory defect with low Total Lung Capacity (TLC). Measurement of TLC requires elaborate equipment, is labor-intensive and time-consuming. It is seldom available in industrial settings or epidemiologic field studies. In contrast, portable spirometry is readily and cheaply done. We sought to determine the value of spirometry in predicting a low TLC and its usefulness in screening for restrictive ventilatory defects. As such, the use of spirometry could avoid unnecessary and costly testing of normal individuals. TLC values for an occupationally referred population of 687 shipyard workers (O) and a clinically refered population of 565 patients at a large Veterans Hospital (C) were compared with a spirometric index. This index was derived from the subject's Forced Vital Capacity (FVC) and the ratio between the One-Second Forced Expiratory Volume and the Forced Vital Capacity ($FEV1_1/FVC$). There was excellent correlation ($p<0.001$) between TLC and the index, with $r=0.66$ in (O) and $r=0.69$ in (C). The index discriminated an abnormally low TLC, i.e., $<80\%$ predicted, with sensitivities of 88% (O) and 70% (C). Specificities were 79% (O) and 82% (C). Overall concordance values were 80% (O) and 78% (C). Because the index identified the majority of subjects with normal or high TLC, its use in screening for restrictive ventilatory defects could obviate a large number of unnecessary lung volume determinations. Spirometry could thus be very useful in epidemiologic field studies of pneumoconioses.

No Paper provided.

PNEUMOCONIOSIS OF DELAYED APPARITION: LARGE SCALED SCREENING IN A POPULATION OF RETIRED COAL MINERS OF THE NORTHERN COAL FIELDS OF FRANCE

P. FRANCOIS • J.M. Prevost • G. Courtois • A. Mas

Charbonnages de France

The coalworker's pneumoconiosis may appear a long time after the exposure to nocive dust has ceased. This is a well established fact. What we don't know exactly is the frequency of such forms of pneumoconiosis of long delayed apparition.

Figure 1. The number of new cases detected among ex-miners increases from year to year; since 1980, it exceeds the number of the cases diagnosed in the population of the active miners.

According to the French legal prescriptions every coalminer in activity is offered a yearly chest X-ray; therefore the endemy of pneumoconiosis is precisely known among the active population. Such a yearly X-ray follow-up is by no means compulsory for the ex-miners, which makes an exact evaluation of the prevalence of the professional disease among the retired miners impossible. However the French Ministry of Health has made recommendations so that an X-ray control may be offered to the miners who have been exposed to nocive dusts of silica, asbestos and iron. In that legal context in 1983, under the direction of Dr. Amoudru, past Chief-Physician of the French Coal Mines, we initiated a large scaled screening among the ex-miners of the coalfield of the North of France.

METHODS

The medical Centre of Bruay en Artois was selected as an experimental base for a screening to be carried out from 1983 to 1986.

The Aims of Such a Screening Campaign

1. Particular epidemiologic interest attached to such a large inquiry among miners and ex-miners;
2. For some cases opportunity to start a regular survey or a treatment;
3. Possible medico-legal implications: certification and compensation of new cases.

Criteria of Selection

The ex-miners were entered into the study on the basis of the following criteria:

1. Absence of any radiological evidence of pneumoconiosis at the time of the retirement;
2. Duration of the dust exposure equal or superior to 5 years;
3. Cessation of any exposure since at least 3 years, without any consideration of age.

Responses to the Proposition of a Medical Check-up—Figure 2

3624 invitations were issued. 3070 ex-miners participated (85% of the total population). That high percentage of participation may be partly explained by the perspective of a possible certification; it is also the result of the prealable campaign of information addressed to the ex-workers and their family doctors.

Absenteeism represents only 15% of the contacted population. Figure 2 shows the main reasons of that absenteeism: illness among the older ones, indifference of some of the younger ones.

RESULTS

The *reading of 3070 radiographs* allowed us to detect not only new cases of pneumoconiosis but also other thoracic diseases which required the following complementary explorations:

1056 clinical check-ups
944 explorations of the respiratory function
72 blood gas analysis
1056 electrocardiograms
223 sputum bacteriological analysis

The 3070 read chest X-rays revealed:

1463 subnormal radiographs
514 opacities sequelae of prior diseases
315 non pneumoconiotic thoracic affections
741 new cases of characterized pneumoconiosis

Subnormal Radiographs: (48%)

Strictly speaking we didn't find any absolutely normal X-ray, which is by no means surprising if we consider the average age and the professional anammesis of the studied population.

The subnormal X-rays consisted of: either an increase of linear shadows of the lungs; small calfications, sequelae of tuberculosis, or a certain degree of fibrosis isolated or associated

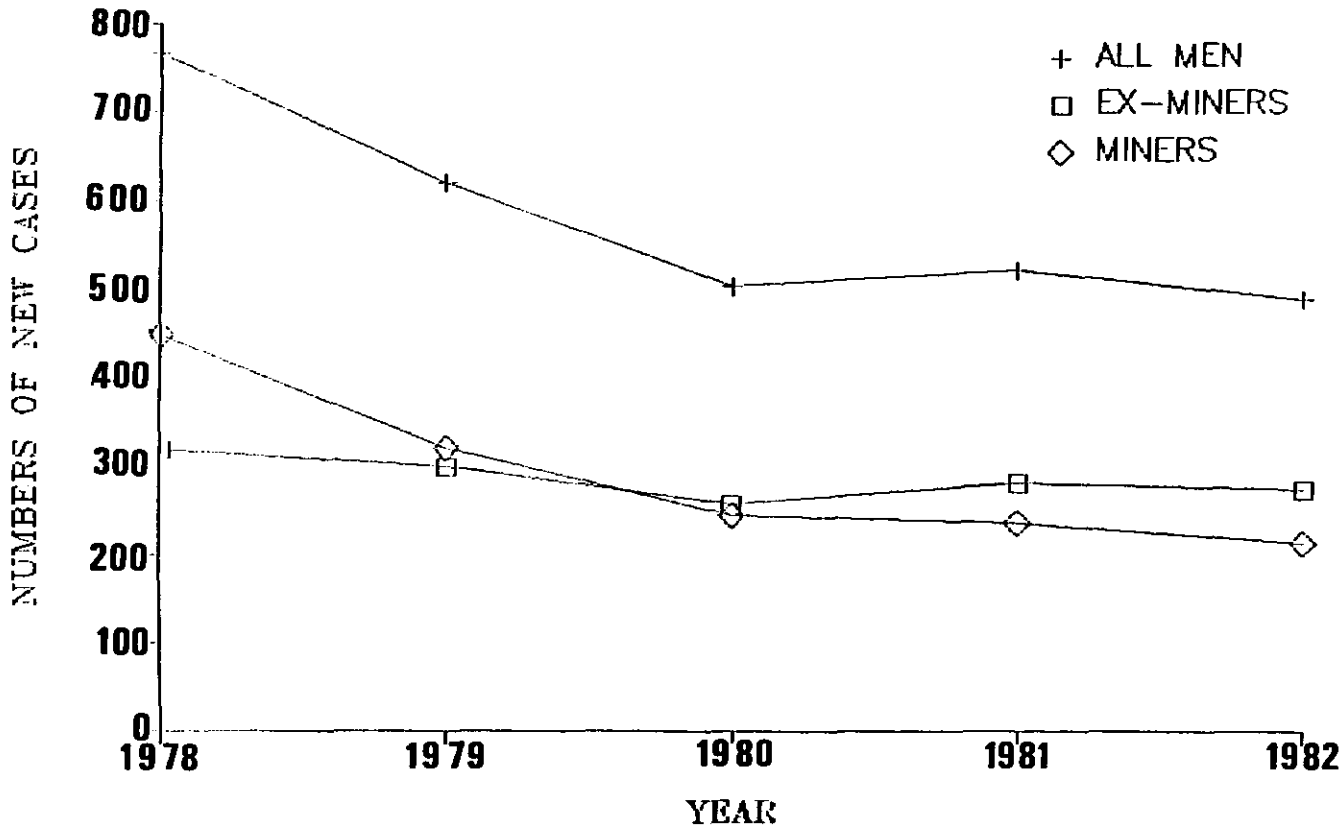

Figure 1. Pneumoconiosis: new diagnoses, northern coal fields of France.

to some fine round opacities.

These data may raise some difficulties of interpretation when dealing with aged people. Is pulmonary fibrosis induced by chronic bronchitis, heavy smoking habits, by the long past of dust exposure, or by an intrication of these various factors?

Opacities Sequelae of Prior-diseases (17%)

1. Sequelae of tuberculosis (184 cases)

   In 25% of these cases considerable mutilations were observed from therapeutic procedures anterior to the era of the antibiotics (artificial pneumothorax, lobectomy, thoracoplasty...) with severe failure of the respiratory function in some cases. In the other cases lesser lesions were observed making the diagnosis somehow difficult when associated with some fine opacities.

2. Sequelae of pleural affections: 308 cases

3. Sequelae of broncho-pneumonic diseases and thoracic traumas: 36 cases.

Evolutive Non Pneumoconiotic Thoracic Diseases: (11%)

- tuberculosis (5 cases)
- cardio vascular affections (174 cases)
- scleroemphysema (110 cases)
- aspergilloma (1 case)
- lung-carcinomas (16 cases)

  Primary cancer of the lung of epidermoid type (8 cases), of anaplasic type (3 cases); adenocarcinoma (1 case).

  Secondary cancers of the lung (4 cases).

Table I shows that we found 741 new cases of pneumoconiosis, which represents 24% of the examined population.

1. Percentages of new diagnosis by age groups (Figure 3): The percentage is above the average for the groups of age 50 to 54 and 55 to 59. The rate of diagnosis notably decreases from the age of 70.

2. Percentage of new diagnosis in relation with the duration of the dust exposure. On Figure 4, it appears that

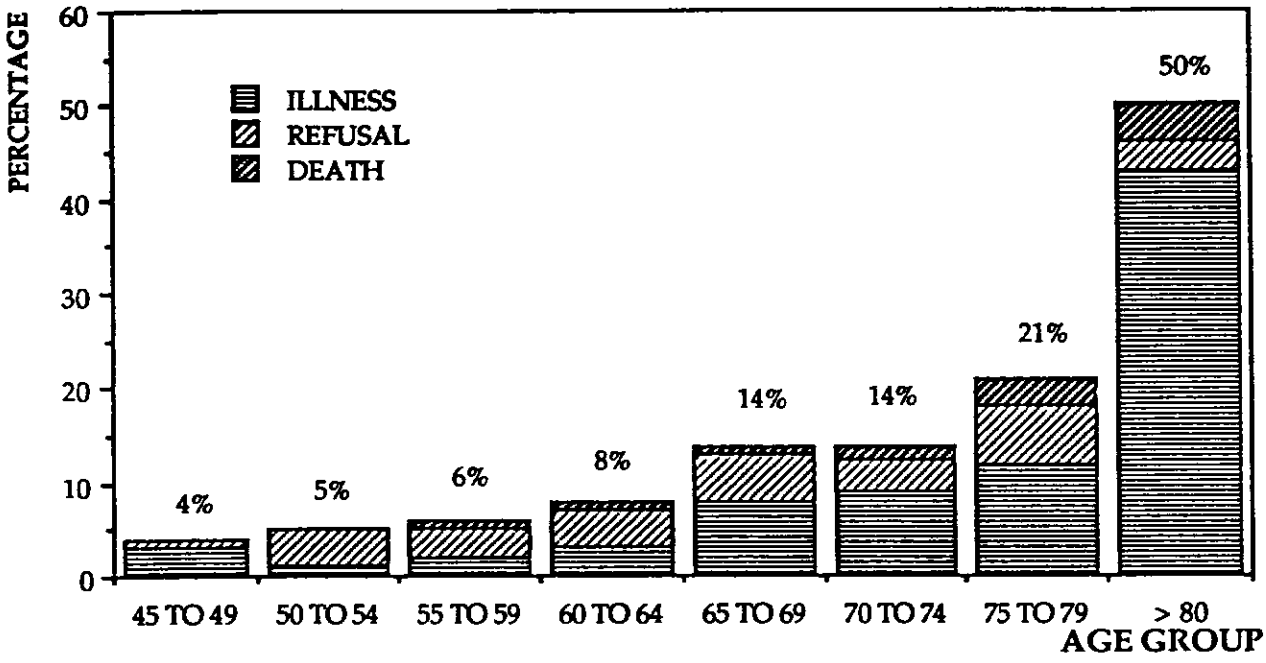

Figure 2. Percentage of non participation in each invited age group.

pneumoconiosis is rarely diagnosed when the dust exposure has been less than 10 years in duration.

3. Smoking habits and delayed cases of pneumoconiosis. Among the 741 new cases we found:

   237 non-smokers (32%);
   90 ex-smokers (12%);
   414 smokers (56%).

   We note that two thirds of the new cases concern smokers or ex-smokers, a proportion of smoking habits roughly equal to that of the general male population.

4. The reading of the 741 radiographs of new cases according to the I.L.O. classification of 1980 (Table II). We used the complete classification for the parenchymal opacities, the short one for the pleural changes.

   a. Parenchymal abnormalities consistent with pneumoconiosis. It must be emphasized that interpretation appears often difficult when dealing with aged miners.

   b. Small opacities: as for their profusion in most of cases there are classified category 1.

   c. With regard to their shape and size: p and q, when predominant, represent 98% of the cases.

   d. The irregular opacities (s, t, u) more often seen among the older miners, are, as a rule, associated with round opacities.

The large opacities account for 10% of the new cases. Six out of the 72 cases required long course oxygenotherapy after blood analysis had been performed. All cases represented a dust exposure superior to 20 years.

Other radiological data recorded: 53 Ax (coalescence of small opacities), 51 em (emphysema) 5 es (egg shell), 50 tb (sequelae of tuberculosis), 46 co (abnormality of the heart silhouette), 22 hi (hilar enlargement), 1 di (distortion of the intra-thoracic organs). Pleural thickening (Pt) was noted only in 13% of cases, such a change being relatively uncommon in coalminer's pneumoconiosis.

To sum up, using the short classification, we found the following repartition:

a. category 1 (69% of the 741 new cases);
b. category 2 (21%)
c. progressive massive fibrosis (PMF) 10%.

Table I
Pneumoconiosis

AMONG 3070 CHEST X RAYS

NEW CASES OF PNEUMOCONIOSIS : 741

24 % OF THE EXAMINED POPULATION

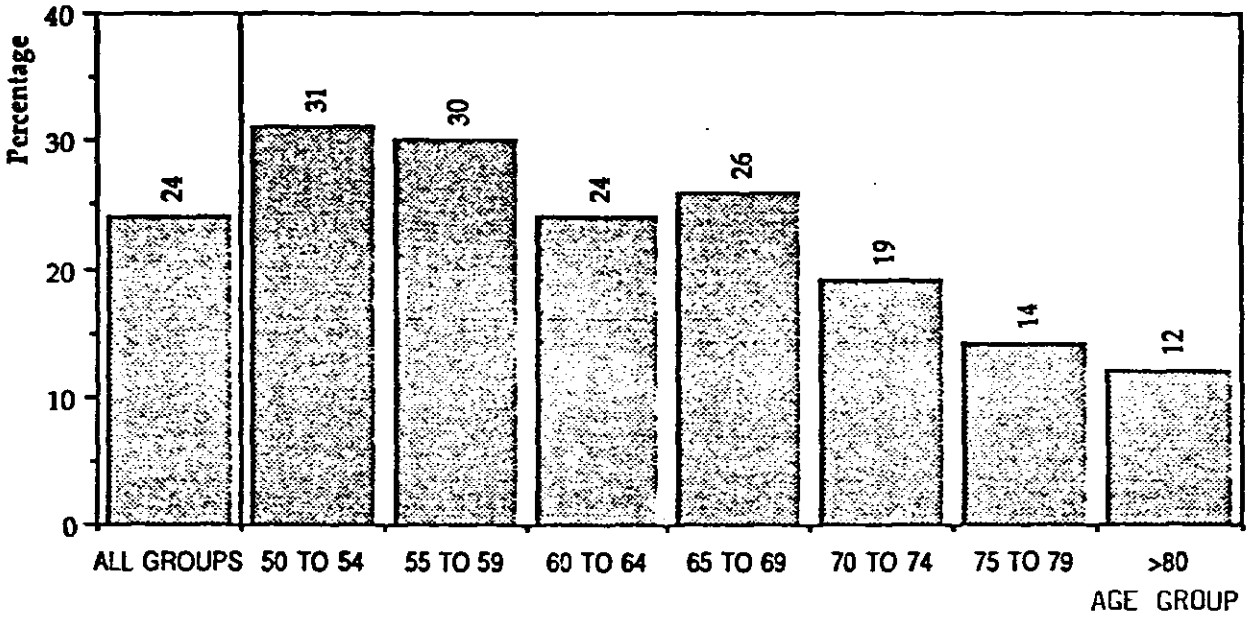

Figure 3. Percentage of new diagnosis by age group.

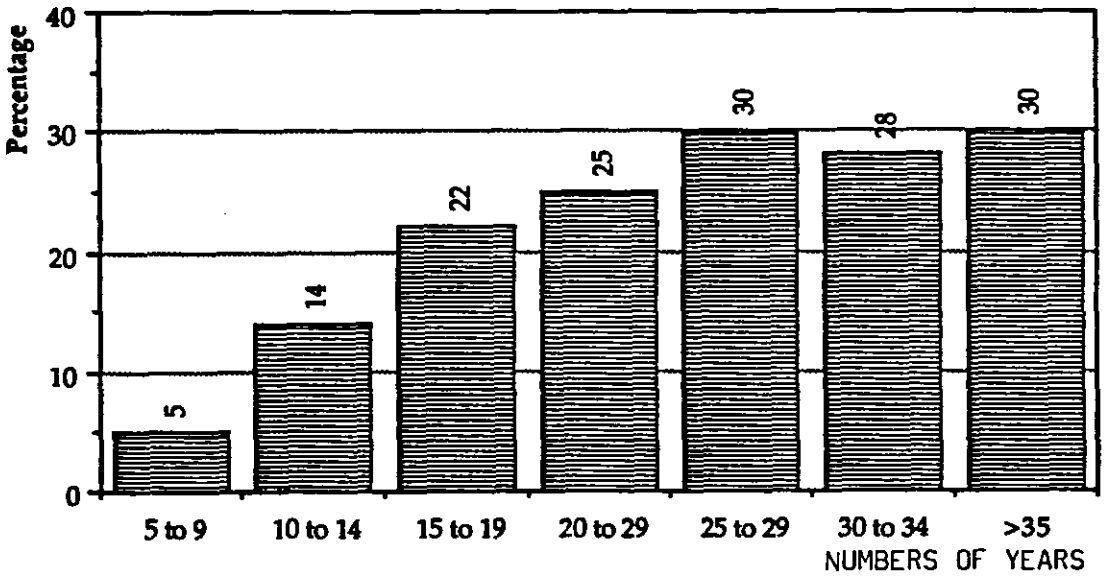

Figure 4. Percentages of new diagnosis in terms of dust-exposure duration.

Table II

New Cases of Pneomoconiosis: 741
The Reading of the Radiographs According to the
ILO Classification 1980

SMALL OPACITIES

PROFUSION	1/1	1/2	2/1	2/2	2/3	3/2	3/3	3 +
NUMBER OF CASES	279	256	107	57	22	14	3	3

SHAPE AND SIZE OF PREDOMINANT OPACITIES	P	Q	R	S - T U
NUMBER OF CASES	75	618	33	15

LARGE OPACITIES

SHADOWS	A	B	C	ALL SHADOWS
NUMBER OF CASES	48	23	1	72

OTHER SYMBOLS

	AX	EM	ES	PT	TB	CO	HI	DI
NUMBER OF CASES	53	51	5	99	50	46	22	1

As an illustration we here present two cases of evident delayed development of pneumoconiosis:

Case No. 1. This 76 year old miner retired 26 years ago after 32 years of exposure to dust. You can see on the left a subnormal radiograph at the time he ceased his work, on the right the radiograph taken in 1983 showing evidence of pneumoconiosis.

Case No. 2. This 66 year old ex-miner, retired 24 years ago after 25 years of dust exposure, with no evidence of pneumoconiosis on X-ray; in 1983, pneumoconiosis is obvious on the radiograph.

From our experience, we should like to emphasize the following points:

1. When dealing with aged ex-miners a good quality of the radiograph as well as an experimented reader physician are equally required.
2. Chest X-ray should be systematically made at the time of retirement to allow a better further evaluation of a delayed pneumoconiosis.
3. At the time of the screening some data of the personal medical work file, former diseases and psychological status particularly, should be taken into consideration in order to foresee some peculiar reactions after a long delayed pneumoconiosis has been diagnosed. In some cases, a supportive psychotherapy may be indicated. As a converse reaction, a 90 year old ex-miner, with a good sense of humour, once declared that from now on with the money of compensation, he could afford a call girl!

CONCLUSION

As a rule our ex-miners have appreciated being offered the possibility of such a post-professional check-up performed by the physicians of the familiar medical center of their coal mine.

From a medical view point that large scaled screening campaign is judged positive since it led to the diagnosis of some non-professional affections in addition to an appreciable number of cases of long delayed pneumoconiosis.

Most of those long delayed pneumoconiosis are radiologically characterized by small opacities of profusion 1 and 2.

The opportunity of such screening campaign may be questionable when dust exposure has lasted less than 10 years or when dealing with old ex-miners over the age of 70.

Finally, the experience of that large scale screening has comforted us in the opinion that the post professional survey appears more and more founded in our industry. Coal miner's pneumoconiosis, owing to a more efficient technological and medical prevention has become nowadays a disease of delayed apparition and that epidemiological evolution all the more justifies the post professional survey of our coal miners. Following the French governmental recommendations in that matter, the medical service of our coal mines gets now more and more engaged in the working up of an adapted post-professional medical follow-up for all our ex-miners.

PREVALENCE OF SILICOSIS AMONG CERAMIC INDUSTRIES WORKERS IN THE CITY OF PEDREIRA, BRAZIL

JOSÉ INACIO DE OLIVEIRA, et al.
DMPS/ASO. FCM/UNICAMP—Campinas, Brazil

ABSTRACT

Due to the onset of several cases of silicosis in the last few years in a small community in the State of São Paulo, where ceramic industry is a major economical activity, an epidemiological survey of all exposed workers has been carried out, in order to assess the magnitude of the problem and to establish a comprehensive programme of control.

Among nearly 4,000 workers submitted to chest X-rays, from fifty industries, 150 cases of silicosis were detected.

At this time, these cases can be described following some epidemiological characteristics such as age groups, sex, race, occupational history and time of suspected exposure, as well as the results of screening spirometries.

No Paper provided.

MULTIPLE CAUSE-OF-DEATH DATA IN PNEUMOCONIOSIS SURVEILLANCE AND RESEARCH

L. WIDEROFF • D.O. Hryhorczuk • J. Holden

Cook County Hospital Department of Occupational Medicine, Chicago, Illinois, USA

ABSTRACT

Multiple cause of mortality data from Illinois were examined to 1) determine the degree of under-reporting in pneumoconiosis vital statistics based on underlying cause at death and, 2) explore the prevalence at death of diseases associated with pneumoconiosis. Five-year multiple and underlying cause of mortality rates of white males were compared at the state and county levels. A matrix was constructed to show the frequency of concurrent diseases.

From 1979-1984, the percentage of cases in whom pneumoconiosis was reported as the underlying cause of death was 29% for CWP, 22% for asbestosis and 55% for silicosis. State rates which included pneumoconiosis as a contributory cause in the numerator were thus 73%, 78% and 46% higher than underlying cause rates. There was a statistically significant geographical difference (p .05) by county in the proportion of CWP cases reported as underlying cause. In the multiple cause analysis, lung cancer was reported in 38% of the asbestosis cases and tuberculosis in 4% of silicotics. One or more forms of COPD were found in 30% of CWP cases. While the concurrence of these diseases is well known, the analysis of multiple cause-of-death data promises new areas for hypothesis generation in pneumoconiosis research. For surveillance purposes, time trends and geographical patterns of co-existing diseases can be monitored. In addition, vital statistics based on multiple cause data more accurately quantify pneumoconiosis mortality, independent of the role which the certifying physician assigns the disease in the causal sequence leading to death.

No Paper provided.

NATIONAL SURVEY OF PNEUMOCONIOSIS SUPERVISION IN JAPAN

YOSHIHARU AIZAWA, M.D. • Tsutomu Takata, M.D. • Keizo Chiyotani,* M.D.

Kitasato University School of Medicine, Kanagawa, Japan
*Rosai Hospital for Silicosis, Tochiqi, Japan

INTRODUCTION

Though there are indications of recent decrease in occupational hazards in Japan, pneumoconiosis still remains quite prevalent.

The radiograph and the statement certifying the results of pneumoconiosis examination are submitted to the Chief of the Prefectural Labour Standards Office if a worker is diagnosed as having signs of pneumoconiosis on the chest radiograph. The mode of pneumoconiosis supervision is determined by the Chief of the Prefectural Labour Standards Office and is based on the assessment of the Prefectural Pneumoconiosis Examination Physician.

Pneumoconiosis statistics are annually issued from the Ministry of Labour.[1] They are based on data collected from each Prefectural Labour Standards Office throughout the country. However, the various modes of pneumoconiosis supervision remain to be established in regard to certain details. The present study, extending from April 1, 1985 to March 31, 1986, was carried out for this purpose.

MATERIALS AND METHODS

Examination and Supervision of Pneumoconiosis

Employers periodically have pneumoconiosis examinations conducted for workers exposed to dust. Workers engaged in the past in dust work may undergo such an examination if they so desire.

Pneumoconiosis examination under the provisions of the Pneumoconiosis Law or administered by Ministry of Labour Ordinance consists in obtaining occupational history related to dust work, a radiograph, clinical chest examination, examination for complications and pulmonary function tests.

Chest radiographs are classified according to the Japanese Classification of Radiographs of Pneumoconiosis. Radiographic appearances are classified into one of six categories (PR1 to PR4C). When pneumoconiotic signs are detected, clinical examination of chest and pulmonary function tests are conducted.

Pulmonary function tests consist in conducting spirometry, obtaining flow volume curve and making blood gas analysis if necessary. Percent vital capacity (%VC) normalized by the regression equation of Baldwin,[2] forced expiratory volume in one second (FEV1%), maximal expiratory flow at 25% FEV over height (V25/Ht) and alveolar-arterial oxygen pressure difference (AaDO2) each has a standard value as the basis for evaluating pulmonary dysfunction. The absence of pulmonary dysfunction is indicated by F(−), requirement for blood gas analysis as F(+) and a considerable degree of pulmonary dysfunction as F(++).

Workers who are presently or have been engaged in dust work are given health supervision. There are four modes of supervision. No. 1 is for the persons considered unaffected by pneumoconiosis while No. 4 is for persons whose radiographic appearances correspond to category 4 (limited to those with opacities larger than one-third the lung field, PR4C), or persons whose radiographic appearances correspond to Category 1, 2, 3 or 4 (limited to those with opacities smaller than one-third the lung field, PR4A and 4B) and who have considerable pulmonary dysfunction due to pneumoconiosis.

The No. 2 supervision requires reduction of exposure to dust, Nos. 3A and 3B require change of work. The No. 4 involves medical treatment which is also administered to persons suffering from complications.

Subjects

Copies of 44,531 statements of the results of pneumoconiosis examination were sent to us from 47 Prefectural Labour Standards Offices. 1,048 statements, not adequately documented, were excluded from those of the subjects analyzed. The copies of 43,483 statements indicated age, sex, mode of supervision, category of chest radiograph, complications, pulmonary dysfunction, history of dust work, symptoms and signs.

Methods

Nine members of the committee, headed by Dr. Keizo Chiyotani, carried out the present study. All data obtained were processed and analyzed by an IBM4341 computer operated in conjunction with SAS at the Kitasato University Computer Center.

RESULTS

Background of Subjects

Age distribution. The ages of 43,483 subjects ranged from 15 to 97 years with the mean and standard deviation being 50.1 and 8.4 years, respectively. 95.1% and 4.9% of the subjects were men and women respectively, whose age means and

standard deviations were 49.9 ± 8.5 and 55.2 ± 7.6 respectively.

40,679 persons were required to take the examination as opposed to 2,804 persons who volunteered for the examination. The mean age of those who took the periodical examination was 49.5, which was less than 59.1 of those who requested it.

Dust work. The types of main dust work were welding (21.9%), excavation (17.6%) and pottery manufacture (16.4%). A person's work was considered that in which he or she had been engaged for the longest time.

Mode of Supervision

General picture. Eight percent (3,483) of submitted cases was diagnosed as negative for pneumoconiosis according to the chest radiograph (No. 1 supervision). No. 2 supervision was found most frequently (74.7%), followed by No. 3A (11.4%), No. 3B (4.6%) and No. 4 (1.3%).

Mode of supervision according to age groups. Nearly all the persons in the age groups younger than 30 were classed as No. 1 or No. 2 supervision as shown in Figure 1. The percentage of No. 2 supervision was less in the older age groups, being 39.1% in the 70-or-older age group, while 80.5% in the 30-39 age group. Older age groups showed requirement for Nos.3A, 3B and 4 modes of supervision than younger age groups.

Mode of supervision according to type of examinee. 77.9% of 40,679 persons who underwent periodical examinations were classed as No. 2 supervision as shown in Figure 2. The percentages of Nos. 2, 3A and 3B were almost equal in 2,804 volunteers.

Mode of supervision according to the type of dust work. The No. 2 mode was most frequent (83.5%) while No. 3B (0.5%) and No. 4 (0.2%) were rarely applicable among welders. Essentially the same modes were found applicable to foundry workers, grinding workers, refinery workers and glass workers.

The No. 2 mode was most frequent (57.3%), with Nos. 3A (19.1%), 3B (11.8%), 4 (4.9%) being somewhat less among excavators. Pottery makers and stonemasons required essentially the same modes of supervision.

Workers exposed to carbon, asbestos and cement indicated intermediate between welders and excavators.

Method for determining applicability of the No. 4 supervision mode. There were 562 persons classed as No. 4 supervision modes based on the considerable degree of pulmonary dysfunction (79.9%) and of PR4C (20.1%). Those evaluated as F(++) constituted about 75% the age groups younger than 60, and about 85% the 60-or-older age groups as shown in Figure 3.

Among those undergoing periodic examinations, 74 persons were classed as No. 4 based on the considerable pulmonary dysfunction (64.9%) and PR4C (35.1%). Of the 488 persons who volunteered for those examinations, 82.2% were classed as No. 4 owing to considerable pulmonary dysfunction.

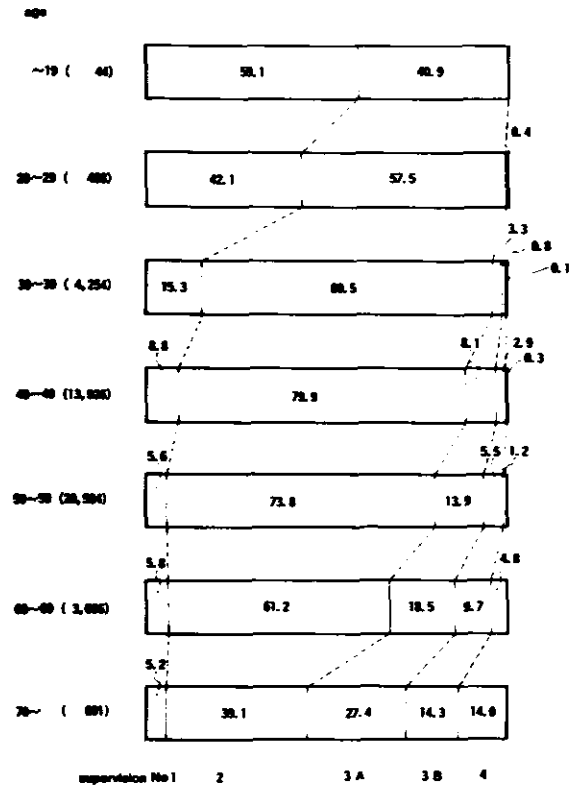

Figure 1. Modes of supervision according to age groups. Numbers in parentheses represent number of persons. Numbers in columns represent percentages of respective modes of supervision in each group.

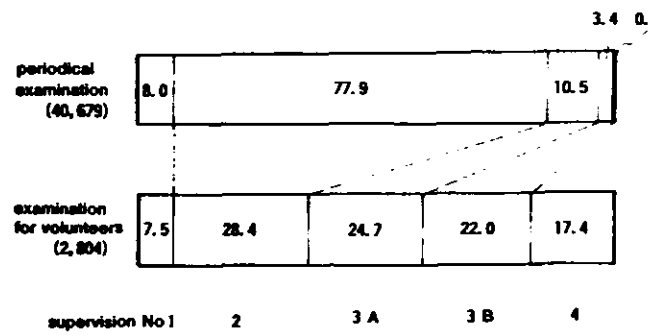

Figure 2. Modes of supervision according to type of examinee. Numbers in parentheses represent number of persons. Numbers in columns represent percentages of respective modes of supervision in each type of examinee.

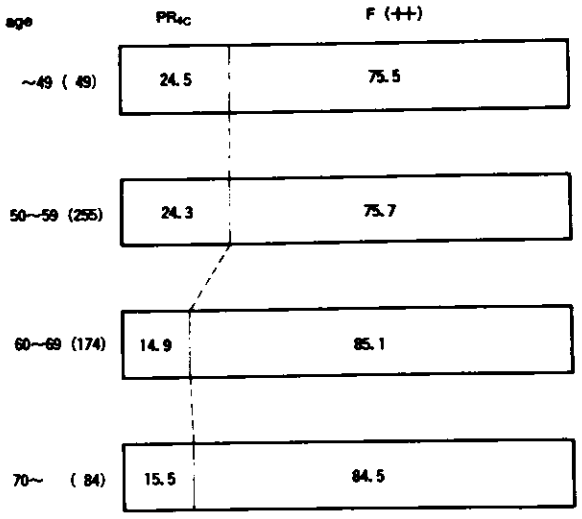

Figure 3. Basis for evaluation of No. 4 supervision modes according to age groups. Numbers in parentheses represent number of persons in each group. Numbers in columns represent percentages of respective bases for deciding on No. 4 supervision.

Complications

816 persons were diagnosed as having one or two complications. The 826 diseases afflicting the subjects were comprised of secondary bronchitis (47.3%), pulmonary tuberculosis (45.0%), pneumothorax (3.6%), tuberculous pleuritis (2.7%) and bronchiectasis (1.3%). Mean age of persons with complications was 59.3, compared to 50.0 for persons without complications.

Chest Radiographs

PR1 was found most frequently (74.8%), followed by PR2 (11.8%), PR0 (8.0%), PR3 (2.1%), PR4A (1.8%),PR4B (1.2%) and PR4C (0.3%). In the age groups younger than 30, PR0 and PR1 were applicable to nearly all persons. The percentage of PR1 was less in older age groups, such as 39.9% in the 70-or-older age group compared to 80.5% for the 30-39 age group. PR2, PR3 and PR4 were more frequent in older than younger age groups.

Pulmonary Dysfunction

Pulmonary function tests were conducted for 40,604 persons not diagnosed as having PR4C or any complications. 74.7% was assessed as F(−), 24.1% as F(+), 1.2% as F(++). F(++) was observed in 14.5% of persons 70 or older, while only in 0.1% of the 30-39 age group.

A considerable depression in %VC or FEV1% was noted in 58.5% of persons assessed as F(++). A considerable depression in V25/Ht and a considerable elevation in AaDO2 was noted in 36.5% and 5.2% respectively of persons thus assessed.

DISCUSSION

Surveys of pneumoconiosis in Japan and other countries have already been reported.[3–7] However, these reports are limited to certain medical facilities,[5–7] areas,[4] and dust works.[3] Simple statistics of classification of pneumoconiosis are published annually by the Ministry of Labour.[1] This paper presents the first detailed study on the supervision of pneumoconiosis throughout the Japanese population.

The subjects studied were persons engaged, either presently or at some time in the past, in dust work and suspected of pneumoconiosis from their chest radiographs. A total of 3,483 persons (8%) were considered to have no indication of pneumoconiosis based on radiographs according to the Chief of Prefectural Labour Standards Office. There were thus 40,000 among 260,629 examinees (15.3%) with pneumoconiotic symptoms according to their radiographs. Since persons with negative pneumoconiotic signs on their radiographs are examined for this disorder once every three years, the prevalence rate may be calculated by dividing 40,000 by 589,758 persons engaged in dust work (6.8%).

The No. 4 mode of supervision requiring medical treatment was found applicable to 1.3% (562 persons) of all the subjects. It frequently applied to elderly persons and those who volunteered for the examination. The percentages of this mode were more than 1% in excavators, stonemasons, asbestos workers and cement workers.

In numerous cases, pulmonary dysfunction was the major basis for deciding on this mode. This was especially so for elderly persons and those who volunteered for the examination. Pronounced pulmonary dysfunction was mainly attributed to depression of %VC or FEV1%, with depression of V25/Ht rating as the second causative factor.

More than 90% of diseases causing complications were secondary bronchitis and pulmonary tuberculosis. The mean age of persons with complications was higher than that of persons without complications.

REFERENCES

1. *Annual guide of industrial hygiene in Japan.* pp. 226-228. Ministry of Labour, Ed. Japan Industrial Safety and Health Association, Tokyo (1986).
2. Baldwin, E.deF., Cournand, A. and Richards, D.W.: Pulmonary insufficiency I. Physiological classification, clinical methods of analysis, standard values in normal subjects. *Medicine* 27:243-278 (1948).
3. Crosbie, W.A.: The respiratory health of carbon black workers. *Arch. Environ. Health* 41:346-353 (1986).
4. Nagahama, F.: The clinical observations on pneumoconiosis in Hokkaido, especially on coal miners' pneumoconiosis. Jap. J. Traumatol. Occup. Med. 34:424-437 (1986).
5. Pulmonary function tests in pneumoconiosis. *The 56th Annual Meeting of Japan Association of Industrial Health*, Osaka, Japan (1983).
6. Supervision of health in pneumoconiosis. *The 59th Annual Meeting of Japan Association of Industrial Health*, Hiroshima, Japan (1986).
7. Yokoyama, T.: Evaluation of pulmonary function in pneumoconiosis. *J. Jap. Med. Assoc.* 90:1587-1593 (1983).

ACKNOWLEDGEMENTS: This study was supported by a grant from the Ministry of Labour in Japan.

AN HISTORICAL REVIEW OF AIRBORNE COAL DUST LEVELS AND THE PREVALENCE OF OCCUPATIONAL LUNG DISEASE IN NEW SOUTH WALES COAL MINES 1948–1988

DR. ROBERT GRIFFITS, M.B.B.S., F.A.C.O.M.

Senior Occupational Physician, Joint Coal Board, Newcastle, New South Wales, Australia

INTRODUCTION

There has been a dramatic reduction in the prevalence of Occupational Lung Disease in New South Wales coal miners following an intensive preventative program commenced by the Joint Coal Board in 1948.

At that time 16% of the 17,204 miners employed in the industry had radiological evidence of pneumoconiosis and 33% had clinical evidence of chronic bronchitis. Most of the 14.8 million tons of coal produced in 1947 was won by hand mining techniques. Ventilation was generally poor and airborne dust counts were high. Particle counts as high as 20,000 particles per cubic centimetre (p.p.c.c.) were recorded in the most dusty operations.

Mining methods have changed considerably since 1948. Widespread mechanization was introduced during the 1950's. Cutting and boring machines were introduced first and in turn gave way to the use of continuous miners.

Bord and pillar mining utilizing continuous miners is the main method of coal extraction today, although longwall mining and open cut mining has been assuming increasing prominence during the past decade. The industry currently employs 16,731 persons and in 1987/88 76.3 million tons of coal was produced. Open cut mining was responsible for 41.4% of coal production, and the output from longwall mining increased significantly to account for 18.7% of total production.

Today only 1% of mineworkers have pneumoconiosis. There are only eight cases of I.L.O. Category Two Pneumoconiosis or greater in the workforce. Progressive Massive Pulmonary Fibrosis (P.M.F.) is an historical curiosity. The prevalence of Chronic Bronchitis has dropped to 12%.

Most mines (even the majority of the longwalls) comply with the current 3 mgm/m^3 gravimetric standard.

GEOGRAPHY

Most coal mining in Australia occurs in the states of Queensland and New South Wales on the east coast. Similar annual tonnages are produced in each state.

In New South Wales mining is principally located in four main areas: the Northern District around Newcastle, the North Western District near Singleton, the Southern District in the vicinity of Wollongong and Camden and in the Western District around Lithgow. Most open cut mining occurs in the North Western District. Longwall mining is progressively being introduced in all districts.

PREVENTION AND MONITORING PROGRAM

In 1939, a Royal Commission conducted by Mr Justice Davidson inquired into the safety and health of workers in coal mines. Regulations to control dust levels were developed following the Commission, but they were not proclaimed until 1943.

In 1945 a second Royal Commission was held. The Commissioner asked Drs. Cilento and Murray and Mines Inspector Brewster to conduct a National Survey of the health of coal miners. One of the main recommendations of their report was the setting up of a medical scheme to allow chest X-ray and clinical examinations of all entrants to the industry. Similar periodic tests at two to three yearly intervals were also recommended for all working miners as a check for the incidence of industrial disease.

A major outcome of the 1945 Royal Commission was the establishment of the Joint Coal Board in 1946, which was given wide statutory powers to control, regulate and assist the coal mining industry. Included was the power to supervise and promote health, with provision to regulate the conditions in the industry with respect to the enforcement of measures for the abatement of dust in mines.

The Board established four Medical Bureaus in 1948 in the chief coal mining centres of Wollongong, Newcastle, Cessnock and Lithgow. A pathology laboratory to study post mortem lung and heart specimens from deceased coal workers was established at the Board's Newcastle Bureau in 1950.

The medical examinations performed by the Board's Medical Officers included the taking of occupational and general medical history, a physical examination and chest X-ray examination. Spirometry was added at a later date.

A comprehensive medical research program was commenced utilizing the post mortem preparations and data obtained during the medical examinations.

The first Pneumoconiosis Prevalence Study in New South Wales was conducted in 1948. A 10% sample of the 17,200 workforce was assessed. 16% of workers were found to have

pneumoconiosis, 4.5% had Category Two or worse, 0.7% had P.M.F. The majority of cases were found in the Western and Southern Districts. There were fewer cases of pneumoconiosis in the Northern District even though many more men worked in this district. This was consistent with the higher coal dust counts that were continually recorded in the Southern and Western Districts.

Dust sampling was first introduced in New South Wales coal mines in the mid 1930's. Early dust results varied widely between different collieries and with different activities within the same mine, largely reflecting differences in ventilation, watering and stone dusting practices.

Processes such as holing, picking down coal, filling skips and shot firing resulted in the production of large amounts of dust. In badly ventilated places dust exposure could be massive. Results following shot firing in one badly ventilated mine revealed a dust count of 20,000 p.p.c.c. one minute after a shot was fired, dropping to 15,000 p.p.c.c. after a further three minutes. In a better ventilated mine where the coal had been previously stone dusted and watered, a particle count of 144 p.p.c.c. was recorded one minute after the shot was fired.

Dust counts associated with the filling of skips varied, depending on ventilation, between 306 and 900 p.p.c.c. The average dust exposure on wheeling roads when skips were moved was 400 p.p.c.c. At certain positions in surface screening plants, counts as high as 15,000 p.p.c.c. were recorded.

In 1943 a "Permissible Airborne Dust Standard" of 700 p.p.c.c. in the 0-10 micron size incorporated into the Coal Mines Regulation Act of New South Wales. The Owens Dust Pump was the designated measuring instrument.

Following the advent at the Joint Coal Board and its engineering services in 1948, intensive periodic dust sampling was introduced into the industry. The Board decided soon after its establishment that all necessary engineering measures for the physical suppression of dust in mines would be undertaken. The most important measures identified were efficient face ventilation, wet cutting and wet loading, the application of water infusion in particularly dry seams and effective roadway consolidation. The Board encouraged the introduction of mechanization.

By 1955, 6.7% of coal production was mechanized and control measures were recorded as satisfactory in 99.2% of work places.

In 1954, the Board established a Standing Committee on Dust Research, which comprises representatives of colliery proprietors, mining unions, Government departments and medical and engineering personnel from the Board. The main roles of the committee were to: monitor the results of dust sampling; evaluate dust hazards; research improved dust control methods; disseminate information; and educate mine workers in matters related to dust control.

In 1957, a new Dust Standard was proclaimed. The upper limit of the size range was reduced to 5 microns and the maximum permissible limits were varied, depending on the free silica content of the material being worked. The maximum permissible standard now became 700 p.p.c.c. for less than 10% free silica; 600 p.p.c.c. with 10-20% free silica, through a scale down to 200 p.p.c.c. with more than 50% free silica.

Average dust counts recorded for the four districts during the period January 1957 to December 1959 were as follows:

Cessnock	142 p.p.c.c
Newcastle	151 p.p.c.c
West	178 p.p.c.c
South	267 p.p.c.c

The Pneumoconiosis Prevalence Study of the three year period 1957-60 indicated that the prevalence of pneumoconiosis (I.L.O. Category $\geq$ 1/0) had dropped to 3.6%. 385 of the 12,518 examined had pneumoconiosis; 116 men had pneumoconiosis X-ray Category Two or worse. There were three cases of P.M.F. Prevalence rates continued to fall.

The 1963–65 prevalence study indicated that 3% of the mining population had pneumoconiosis, 0.4% (28 men) had Category Two or worse disease and P.M.F. had become non-existent.

In 1967, the Dust Standing was again amended, following medical advice that particles less than one micron in size were relatively unimportant. Only particles in the 1–5 micron size were to be measured. The standard was amended to:

175 p.p.c.c. with less than 10% free silica
150 p.p.c.c. with 10–20% free silica
100 p.p.c.c. with 20–30% free silica
75 p.p.c.c. with 40–50% free silica
50 p.p.c.c. with 50% or more free silica

Continuing improvements in ventilation and dust suppression resulted in further lowering of average dust counts and reduction in the prevalence of pneumoconiosis (see Tables I and II).

By 1982, the average particle count had dropped to 46 p.p.c.c. in the Cessnock/Newcastle District, 105 p.p.c.c. in the Western District and 109 p.p.c.c in the Southern District. The prevalence of pneumoconiosis I.L.O. Category I or greater had fallen to 1.5%, the prevalence of Category 2 or worse was now 0.04%. 12.8% of mineworkers and Chronic Bronchitis.

In 1984, particle counting was superseded by the introduction of personal gravimetric sampling. The regulations specified a limit of 3 mgm of respirable dust/m^3 for dust other than quartz-containing dust. (Quartz containing dust is that dust which contains a quantity of quartz greater than 20% mass of the total sample taken.)

Five members of each production crew on all production shifts are sampled. Longwall production units are sampled at intervals not exceeding six months. Continuous miner units, surface and outbye areas of underground mines and hazardous areas in open cut mines are sampled at intervals not exceeding twelve months.

The personal monitoring equipment that has been adopted is

lightweight with a battery operated pump carried on the person and incorporates a plastic tube from the pump to the cyclone which is fitted within a forward facing hemisphere of 300mm of the wearers mouth/nose.

If any sample exceeds the maximum allowable limit of 3.0 mgm/m^3 a resample must be taken within seven working days in similar circumstances to those existing when the sample was collected. The manager may be directed to carry out additional dust suppression procedures and sampling shall continue at appropriate intervals until satisfactory dust control modifications have been incorporated.

CURRENT SITUATION

The dust suppression results achieved in New South Wales have resulted in the virtual elimination of coal miners pneumoconiosis from the industry. Most continuous miner and longwall units comply with the new gravimetric standard (see Table III). Difficulties however are being experienced on some longwall faces in meeting the standard. In these situations personal respiratory protection is being used whilst

Table I

Average Particle Counts (p.p.c.c.)

DISTRICT	1957/59	1962/63	1967/68	1973/74	1975/76	1981/82
Cessnock	142	104	49	76	61	46
Newcastle	151	149	56	34	39	46
West	178	140	60	98	94	105
South	267	266	100	121	124	109

Table II

Changes in the Prevalence of Pneumoconiosis, Chronic Bronchitis and Obstructive Chronic Bronchitis with Time

	1984	57-60	63-65	71-74	77-80	80-83
Pneumoconiosis:						
ILO > 1/0	16.0%	3.6%	3.0%	3.0%	2.0%	1.7%
Category 2 or worse	4.5%	1.0%	0.4%	0.13%	0.06%	0.04%
Chronic Bronchitis						
All cases	33.0%	-	21.0%	17.6%	13.6%	12.8%
Obstructive C.B.	9.0%	-	6.0%	7.2%	3.3%	2.8%
Smokers	-	-	62.0%	72.0%	67.0%	63.0%
% Workforce examined	10.0%	85.0%	60.0%	96.0%	100.0%	100.0%

Table III

Maximum Dust Concentrations*
September 1987-July 1988

Respirable Dust Concentration mg/m3	Longwall		Other Underground		Surface	
	No	Cumulative Frequency %	No	Cumulative Frequency %	No	Cumulative Frequency %
0 - 1	-	-	25	20	43	72.8
1 - 2	26	26	64	71	10	89.8
2 - 3	35	61	23	89.6	4	96.6
3 - 4	19	80	8	96	-	96.6
4 - 5	8	88	3	98.4	-	96.6
5 - 6	2	90	-	98.4	-	96.6
6 - 7	3	93	2	100	-	96.6
7 - 8	2	95	-	100	1	98.3
8 - 9	2	97	-	100	-	98.3
9 - 10	1	98	-	100	1	100
10 - 11	2	100	-	100	-	100

* Maximum reading of each set of 5 samples taken on each shift monitored.

further engineering measures are being developed. Although the reduction in the prevalence of pneumoconiosis has been outstanding this should not lead to complacency. Appropriate dust monitoring and medical surveillance should be maintained.

It is no longer appropriate to perform chest X-ray examinations at 2 to 3 year intervals given the low prevalence of occupational lung disease. The frequency of chest X-ray examinations will in future be determined by the results of gravimetric sampling. Personal gravimetric sampling will provide more meaningful assessment of dust related health risk.

REFERENCES

1. Clark, T.M.: Australian Experiences in Coal Dust Suppression. *Ann. NY Acad. Sci.* 1972 200:797-807.
2. Leigh, J., Wiles, A.N.: Chronic Bronchitis in Coal Workers in New South Wales, Australia. *Proc. of VI International Pneumoconiosis Conference*, Bochum FRF 1983 1:201-211.
3. Glick, M., Clark, T: Engineering Pneumoconiosis from the New South Wales Coal Industry. *Proc. of III International Conference on Coal Research*, Sydney, Aust. 1976 1:F.1-F1.11.
4. Glick, M.: Pneumoconiosis in the Coal Mining Industry, N.S.W. *Proc. of II Australian Pneumoconiosis Conference*, Sydney, Aust. 1978 D1-D1.9.
5. Cilento, R., Murray, H., Brewster, D.: *Report on a National Survey of the Health of Coal Miners*, Commonwealth of Aust., 1945.
6. *Joint Coal Board Annual Reports* 1948-1987.

REPORT ON THE "INTERNATIONAL SYMPOSIUM ON PNEUMOCONIOSES" IN SHENYANG, CHINA, 30 MAY–2 JUNE 1988

H. IDEL,* P.D. Dr. • K. Robock,† Prof. Dr. • H.-W. Schlipköter,‡ Prof. h.c. Dr.

*Institut für Hygiene, Universität Düsseldorf, FRG
†Bergbau-Forschung GmbH, Essen, FRG
‡Med. Institut für Umwelthygiene an der Universität, Düsseldorf, FRG

The first symposium on pneumoconioses to be held in China was organized by the Institute of Occupational Medicine, Chinese Academy of Preventive Medicine, Beijing, China (Professor Li), the Shenyang Research Institute of Industrial Hygiene and Occupational Diseases, Shenyang, China (Professor Zhao), and the Medical Institute of Environmental Hygiene at the University of Düsseldorf, West Germany (Professor Schlipköter). Of the 150 participants attending, 127 came from 20 different provinces in the People's Republic of China, and 23 came from 8 European countries, the USA, Japan and the WHO. A total of 74 read papers and 34 poster papers were given, on the following subject areas:

- Technology of Dust Prevention and Dust Measurement
- Epidemiology
- Etiopathogenesis and Pathology of Pneumoconioses
- Diagnosis
- Therapy.

On the first of these subject areas, reports were given of the results of person-related dust exposure measurements to supplement stationary dust measurements in order to get a better view of the personal dust exposure, which can vary very widely. The measurement strategies used in the European countries and in the USA were described and discussed, i.e. the frequency and location of gravimetric sampling and the techniques and different types of equipment used for taking the samples, including tyndallometer methods for measuring dust concentration. The basis used here remains the Johannesburg Convention and the ISO definition for measuring and assessing respirable (alveole-penetrating) dust, as was also clear from findings reported here from animal trials. The measurement of inhalable total dust (with particle sizes up to over 100 μm aerodynamic diameter) as practised hitherto in China and the gravimetric measurement of asbestos dust at workplaces were critically discussed. The problems of measuring the quartz content as a guide parameter of the fibrogenic risk of different dusts were discussed, and the importance of the surface properties and lattice structure properties of the quartz or dust particles was pointed out. Detailed reports were also given on measurement of welding fumes, on engineering methods of controlling dust in coal mines, and on person-related dust protection methods.

On the second of these subject areas, papers were read and discussed on epidemiological studies in coal mines, in the asbestos industry, and in workers exposed to flax dust and to welding fumes, and on the incidence and development over time of silicosis, asbestosis, lung cancer, mesotheliomas and allergic disorders. One of the objectives in China is to establish permissible limit values for various substances and to adopt internationally recognized measurement methods, in order to be able to make international comparisons of epidemiological findings. By applying dust control methods, and also in particular by treating cases of tuberculosis, it has been possible in, e.g., the tungsten mining industry to prolong average life from 36 years (1956) to 58 years (1987) in cases of silicosis or silicosis/tuberculosis.

On the next subject area, the aetiopathogenesis and pathology of pneumoconioses, the importance of the particle deposition and particle clearance rates for the aetiology of pneumoconiosis were noted. Also the bronchoalveolar lavage (BAL) was emphasized as an important parameter for assessing the course of a pneumoconiosis. Here, important factors are the total number of lymphocytes, the ratio of the individual lymphocyte populations, and evidence of mediators. In addition to the BAL findings, reports were given of serological changes occurring in silicosis, some of which affect humoral defences or are of interest as autoimmune phenomena: elevated levels of coeruplasmin, fibronectin, interleukin I, phospholipids and complement complex C3, and also of lysozyme, angiotensin-converting enzymes, circulating immune complexes and anti-nuclear antibodies. These serological changes can be almost completely inhibited by administering silicosis-effective substances such as PVNO and Tetrandrin.

As special histological characteristics of silicosis, attention was drawn not only to the criteria already mentioned but also to the deposition of collagen types I & III and fibrinonectin as markers for the fibrotic process, and to multiplication of collagen type IV and laminine as indicators of blood vessel proliferation. Reports were given of studies on the use of (compressed-air) gun-placed concrete at high pressure in tunnel building and the effects—especially of the quick-setting additives used—in animal trials.

In the subject area of diagnosis of pneumoconioses, parameters suitable for early diagnosis of asbestosis were reported: bibasal crepitation as an indicator for alveolitis, siderocytes in the sputum, and presence of asbestos bodies and fibres as indicators of exposure. The reduced elasticity of the lung due to interlobar and perivascular fibrosis causes

disorders of lung perfusion and thus a restrictive insufficiency of ventilation with reduced gas exchange, even in the earliest phase of the disease. A computer aided system of classifying pneumoconioses was also described, and the benefits of computer radiography and computer tomography were described in detail. The importance of studies which collect data on miners starting before they ever go underground was emphasized, so that early and also short-term effects can be detected. Regarding X-ray diagnosis of pneumoconioses in China, it is important to note that from 1986 onwards, Chinese X-ray diagnosis complies with the ILO classification of 1980.

On the subject area of therapy, several authors reported on successes with inhalation and injection therapy with polyvinylpyridine-N-oxide (PVNO) in silicosis patients. Chinese participants presented clinical trials on also additionally administering derivatives of Piperaquin and aluminium, covering more than 3000 cases treated. In vitro studies have shown that aluminium, zinc, nickel and cadmium likewise have a protective effect on the cell surface of macrophages against quartz. The same effect is reported from a Chinese antisilicosis drug "Reduquin." The opinion held hitherto, on the basis of previous studies, that Tetrandrin in vitro has a cytotoxic effect on macrophages, has been contradicted by new studies showing that Tetrandrin markedly inhibits the quartz-induced cytotoxicity against macrophages, as measured by oxygen consumption, superoxide anion release, and hydrogen peroxide release. The progress made in the therapy of silicosis as outlined in these studies is of especial importance in China, where there is still a high incidence of new cases of progressive silicosis.