PROGRAMME FOR INTERVENTION AGAINST ASBESTOS RELATED DISEASES IN THE COUNTY OF TELEMARK, NORWAY

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INTRODUCTION

Although the relationship between exposure to asbestos and pneumoconiosis and lung cancer was revealed some 85 and 60 years ago respectively, scientists are still preoccupied with quantification of these relationships. Much work has been carried out both to remove asbestos and to minimize exposure in work places. Quite little has been done to reduce disease risk among the great number previously exposed subjects.

Attempts have been made to quantify the public health significance of past exposure to asbestos.[5,9] In Norway it has been estimated that 125–150,000 people have been exposed during the past four-five decades to an extent which is detectable in population based studies.[8] In our country no one has carried out intervention among people at high asbestos related risk. In fact, only few scientists have been willing to indulge in the task of stimulating risk reduction and assisting the high risk people to reduce their individual risk.

Our department, which is located in the county of Telemark, Norway, has diagnosed about 700 cases of asbestos-related illnesses during the past 10 years. The cases are mainly lung cancers, mesotheliomas, asbestosis, and pleural plaques. A number of cohort studies and case-control studies carried out among the county population has confirmed that past asbestos exposure has contributed 40 to 45 percent of the environmental causes of lung cancer among the local male population.[4,6,7,8] This high contribution to the "causal weight" is calculated by using etiologic fraction estimation.[7,8] Based on these and other local studies it has been estimated that 11–12,000 asbestos exposed persons are living in the county. We have collected exposure information on about 5,500 of these, mainly males. The lung cancer incidence in males in this county is about 30% higher than in the country as a whole.[1] The total male population in the county is about 80,000, of whom 33,400 are over 39 years old.[4]

These findings have inspired us to start an intervention study of determinants for increased asbestos related disease risk among males in the county. The purpose of the study is to reduce asbestos related disease risk and to prevent illnesses which otherwise would be caused by asbestos or by previous exposure to both asbestos and tobacco smoke. Methods

We have designed a programme in which these 5,500 subjects serve as base for recruitment of subjects assigned for intervention. As a large proportion of these subjects have been identified through a screening programme,[4] where age exceeding 39 years was one of the inclusion criteria, the majority of the subjects are over 40. Most of the other subjects, who have been identified as asbestos exposed through other epidemiologic studies or through clinical surveys, are also above 40 years of age.

We have decided to intervene only against those determinants which give high risk for development of asbestos related lung cancer in males as the primary activity in the early phase. The intervention is planned to comprise two elements;,

a) Information intervention among previously asbestos exposed present smokers, by doctor or nurse, counselling on the potential great lung cancer risk reduction among these combined exposed subjects; and

b) A programme for intensive screening for lung cancer among previously asbestos exposed previous and present smokers.

Evaluation of the results is planned to measure the effect on the smoking prevalence in the intervention group, and the long term effect on lung cancer incidence and mortality, mortality all causes, and mortality due to other asbestos related diseases.

We intend to estimate each participants a priori risk of developing lung cancer and subsequently to use this risk as criterion for determining to which of the two intervention groups the subject is to be assigned. For estimation of the individual a priori lung cancer risk, one needs to know; a) each subjects individual exposure history to lung cancer determinants, and b) to have a set of information from the literature which makes it possible to assess each subjects risk, when the accurate exposure history is known. At present it is not possible to take genetic disease determinants into account in the risk estimation.

For each participant we need to obtain accurate information on the duration and the intensity of past exposure to all major lung cancer determinants. By taking a detailed, individual occupational history, as well as history of exposure to tobacco smoke and alcohol, we have already obtained sufficiently detailed exposure information from about 2,000 subjects. From another 3,500 subjects we have obtained information on exposure to asbestos and tobacco smoke, but supplementary information is needed to be able to carry out assessment of the lung cancer risk. It is also intended to continue collection of exposure information in another 22,000 subjects in whom we have obtained only that exposure information which has been needed to assign these subjects to job categories in previous epidemiologic studies.

From the data on cancer incidence in the total Norwegian population, which have been collected by the Norwegian Cancer Registry since 1953, it is known that the present average a posterior risk for lung cancer in the Norwegian male population increases from about 1×10^{-4} at the age of 40–44 to 15×10^{-4} and even higher at the age of 65–69 (Figure 1, line a).

These risk levels are average levels for experienced lung cancer risk in the general male population. The levels are outcomes from exposure to a range of disease determinants that characterize the past exposure situation for the general population. The individual risk levels, which have lead to these population based risk levels, ranges from low levels among subjects with hardly any exposure to high levels in subjects with previous exposure to a multitude of strong disease determinants.

It would be preferable to have access to reference levels for lung cancer which were uninfluenced by external disease determinants. However, such reference entities are not available. We have therefore decided to apply the national age standardized lung cancer incidence as reference entity for estimation of those risk levels which should serve as criteria for assignment to either of the two intervention groups.

We have chosen to assign those subjects to the subgroup for information intervention who, between five and 25 years from the date of enrollment, are extrapolated to have an a priori lung cancer risk five times or more higher than the national age adjusted background level (Figure 1, line b). Those subjects who are estimated to be at 10 times or higher lung cancer risk than the reference level at the time of enrollment, or who reach this risk level during the study, are to be enrolled into the lung cancer screening group (Figure 1, line c).

The means of intervention have been planned as follows:

a) The information intervention is designed with the purpose to reduce the a priori lung cancer risk by means of providing individually designed oral and risk-determined written information to the study subjects. The content of the information will be different for each subject, and is to be designed to meet each persons needs. These "needs" are determined on basis of the available information on the relevant disease determinants which has been collected beforehand by means of individual work histories an individual information on the non-occupational disease determinants. The magnitude of the a priori lung cancer risk is to be estimated by comparing each subjects past exposure with comparable group based exposure information in published literature. This literature information on relative rate ratios at given past exposures, is to be multiplied by the absolute a posteriori risk at the given ages in the cancer registry data. This approach also enables us to extrapolate the individual a priori lung cancer risk to different points in time in the future. These extrapolated risk estimates are also to be taken into account for the content of the information designed for each participant.

b) The lung cancer screening is planned to be based on two-angle pulmonary X-rays every four months and on yearly three-day exfoliative cytology examination among the members of the high risk groups aged 50 to 69, as these are defined above. Only those participants who exceed an estimated yearly a priori lung cancer risk of 80×10^{-4} will be assigned to triannual screening, as indicated by the broken line c in Figure 1. Those high risk members who do not exceed an estimated risk of 80×10^{-4}, will be screened biannually by two-angle pulmonary X-rays. (The risk among heavy smokers rarely exceeds 60×10^{-4}).

In order to make interpretation and evaluation of the study outcome possible, the study is in need of a kind of "unit" which is applicable both in presence and in absence of intervention. We consider "gained healthy years" among the members of the study group to be an adequate unit for judging the results. Reduced number of exposure-related lost years of life in the study cohort is assumed to be a natural consequence of increased number of healthy man-years. Therefore, gained years of life could also serve as a "unit" for measurement of the outcome of the two strategies for intervention.

DISCUSSION

The choice of frequent X-rays and the less frequent cytology examinations is based on recommendations from the Early Lung Cancer Cooperative Study,[1] which indicated that two-angle lung X-rays are about four times as efficient in detecting early lung cancer as is exfoliative cytology examinations.

We have also considered to chose fixed a priori levels for lung cancer risk as enrollment criteria for each of the two intervention groups. By doing that, assignment to either of the two intervention groups would have taken place when the estimated individual a priori risk exceeds either of these two fixed levels. However, as the experienced a posteriori risk for lung cancer increases with age, (Figure 1, line a) fixed a priori risk levels would have given older people preference before young subjects. It seems likely that individual information intervention may lead to a greater risk reduction when given to high risk groups at young age, than when given to older subjects with a comparable high a priori risk. Therefore, fixed risk level across the age groups might lead to reduced efficiency.

For interpretation and evaluation of the results, we are faced with the same difficulties as other researchers who have indulged in the problem of prospective health assessment.[10] A "controlled" study, in the sense that half of those subjects who are eligible for the study were assigned to the study group and the other half to the reference group, is one possible way to get a reference group. In the present study, however, where a positive outcome of the intervention seems likely, it is difficult to leave half of the group without intervention.

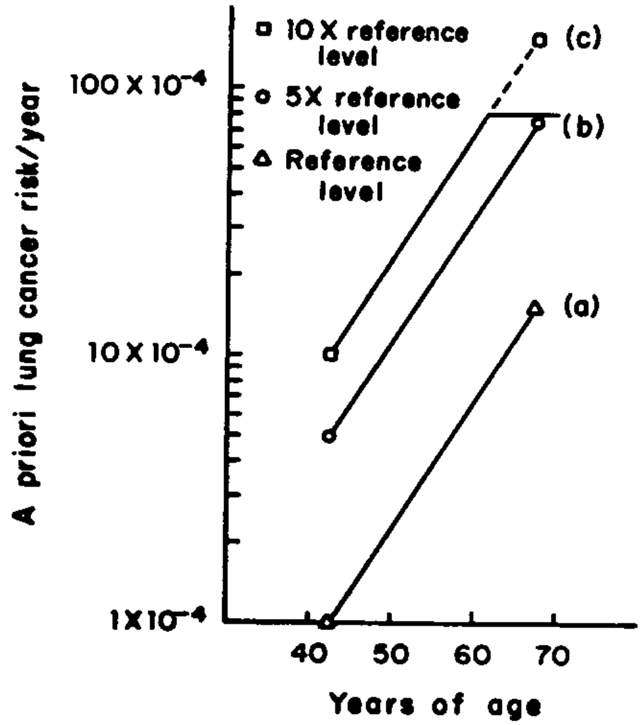

Figure 1. The figure illustrates the a posteriori experienced lung cancer risk (line a) and the a priori lung cancer risk criteria for assignment to the groups for information intervention (line b) and X-ray screening (line c), respectively. Those subjects with risk exceeding the horizontal part of line c are assigned to triannual screening.

We have decided to deal with the problem of evaluation in a similar way as was done in a New York study on the effect of smoking cessation in asbestos workers.[10] In this study the lung cancer mortality was compared among those who had stopped smoking and those who had not. As the numbers are likely to be small in the present study, such a method would allow us to apply intervention on the whole identified population, and subsequently use those who do not participate as reference entity.

In groups which have been heavily exposed to one or two major disease determinant, we consider screening for lung cancer useful only after a presumed development time ("latency period") of 15 to 20 years has elapsed from the first significant exposure. When applying this view, lung cancer screening has biological meaning in relation to the disease determinants at issue only after this presumed development time. When the past exposure has been low, screening only has biological meaning even later.

Depending on the obtained results, in the first place in terms of reduced smoking prevalence in the target group, and later in terms of reduced incidence of lung cancer, the study is intended to carry on as long as past asbestos exposure is considered to be a significant disease determinant in the target population. As reduction in smoking prevalence in the intervention group is to be a prime effect in the present study, one might also expect reduction in smoking related disease incidence and mortality. It is the intention to expand the study to include other major disease determinants in the local population. Such expanded intervention will be performed in close cooperation with the local general practitioners, occupational health physicians, and the hospital.

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BRAZILIAN PROGRAM FOR PNEUMOCONIOSIS PREVENTION

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Brazil is a developing country located in South America and has 135 million people out of which 55 million are active workers. Economically speaking, Brazil is the 8th largest country in the world.

Until 1950 Brazil was basically an agricultural country. From that time on, the manufacturing industry boomed, resulting in an increase of the mining activities. This made a large number of workers to be exposed to dust which are harmful to their health.

Figure 1 shows data related to this serious problem in Brazil and the continuous increasing number of potentially exposed workers. Due to the fact that until last year all measures in Occupational Hygiene and Medicine areas were taken individually in Brazil, to date there are no available data on this matter. Thus, Brazil Ministry of Labor and FUNDACENTRO have been led to set forth a program for Pneumoconiosis Prevention, following the evample of the developed countries.

PURPOSE

The purpose of this program is the control and the reduction of pneumoconiosis cases through primary, secondary and tertiary integrated preventive measures. Primary prevention consists of the workers' dust exposure elimination through the proposition and adoption of environmental control measures, as well as the diffusion of information about the exposure effects and its relationship with the workers''s personal characteristics. Secondary prevention implies the early detection of all pathological conditions of the workers, particularly before the onset of pneumoconiosis symptoms. And tertiary prevention involves the minimization of the medical-social complications resulting from pneumoconiosis by means of treatment of the disease and occupational rehabilitation.

In order to attain this purpose, short and medium-term measures were taken, such as:

a) identification, estimation and registration of the potentially exposed working population, and of the companies and activities which cause pneumoconiosis hazards;

b) workers and employers' awareness of health hazards caused by pneumoconiotic dust exposure. The diffusion of information about prevention risks and techniques by means of events and educative material will help the workers and employers' awareness;

c) training of experts for dust environmental evaluation and pneumoconiosis medical evaluation;

d) control of dust content in work places and medical control of the exposed population;

e) establishment of pneumoconiosis multidisciplinary centers comprising reference laboratories where environmental and medical analyses, including gravimetric, diffractometric, microscopic and radiological analyses may be carried out;

f) improvement of occupational safety and medicine legislation concerning the prevention of occupational pneumoconiosis;

g) subsidies for inspection measures provided by Brazil Ministry of Labor;

h) subsidies for implementation of epidemiological surveillance programs through epidemiological data obtained from cross-sectional and longitudinal studies of the population exposed to pneumoconiotic dust;

i) incentives to research into the occupational pneumoconiosis prevention in engineering and medicine areas, which can be developed at institutional level or in graduation and post-graduation courses.

COVERAGE

For a better use of the available material and human resources we decided, firstly, to develop the program in only six Brazilian states, where the largest number of mining and manufacturing industry workers are concentrated (70% of the whole working population in Brazil). Figure 2 shows the distribution of mining and manufacturing industry workers in Brazil.

In the beginning, we will control the exposure of workers only to coal and crystalline silicates, including silica and asbestos which are the causers of a high percentage of occupational pneumoconiosis cases. Figure 3 shows the district chosen for the development of the pilot plan, where the main Brazilian asbestos and coal mines, and the largest number of mining and manufacturing industry workers exposed to crystallized free silica dust are concentrated.

PROGRAM ACCOMPLISHMENT

The program is being carried out by the Ministry of Labor and the Jorge Duprat Figueiredo Foundation for Occupational

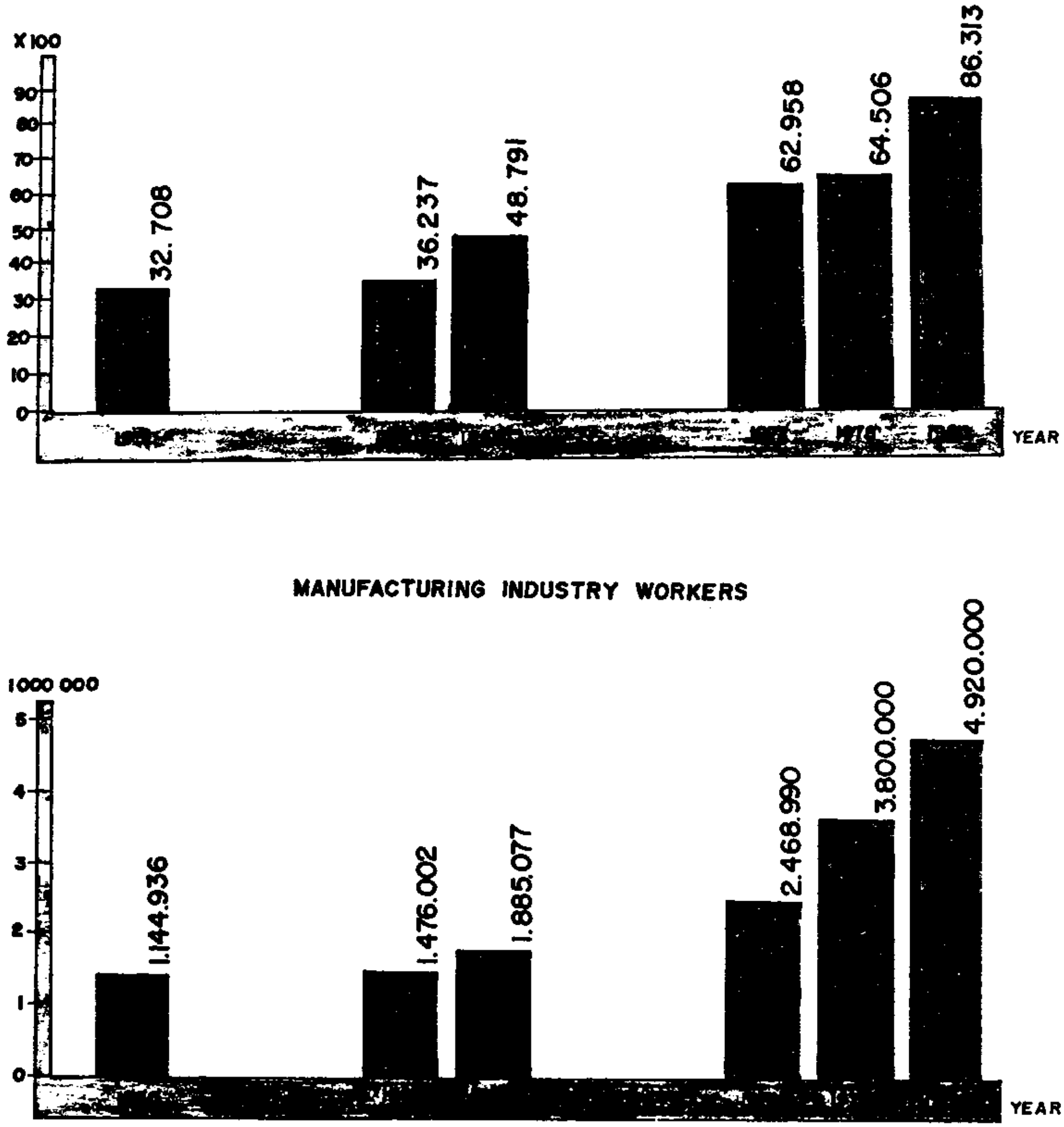

Figure 1. Labor comparative table (1950/1980).

Safety and Medicine—FUNDACENTRO—a nonprofitable entity, which is part of the Ministry of Labor. It was established to conduct research, develop occupational accident and disease prevention programs, and provide technical assistance to public and private organs responsible for occupational safety, hygiene and medicine policy. This program will be successful if workers, employers and Brazilian organs for the prevention of occupational diseases will participate actively in it.

In order to attain the predicted purposes, several steps were estipulated. Some of them will be carried out simultaneously.

In step I, data on exposed workers and data on pneumoconiotic dust exposure sources are being updated, and information channels are being created, since there is no organized information today about the exposure of workers to environmental agents in Brazil.

Questionnaires on administrative data, on registration of industries, and on operational data aiming at identifying the main hazardous operations, the products involved, and the existing control measures were prepared. The predicted number of questionnaires to be applied, in this first step, in all hazard industrial sections, such as mining, ceramics,

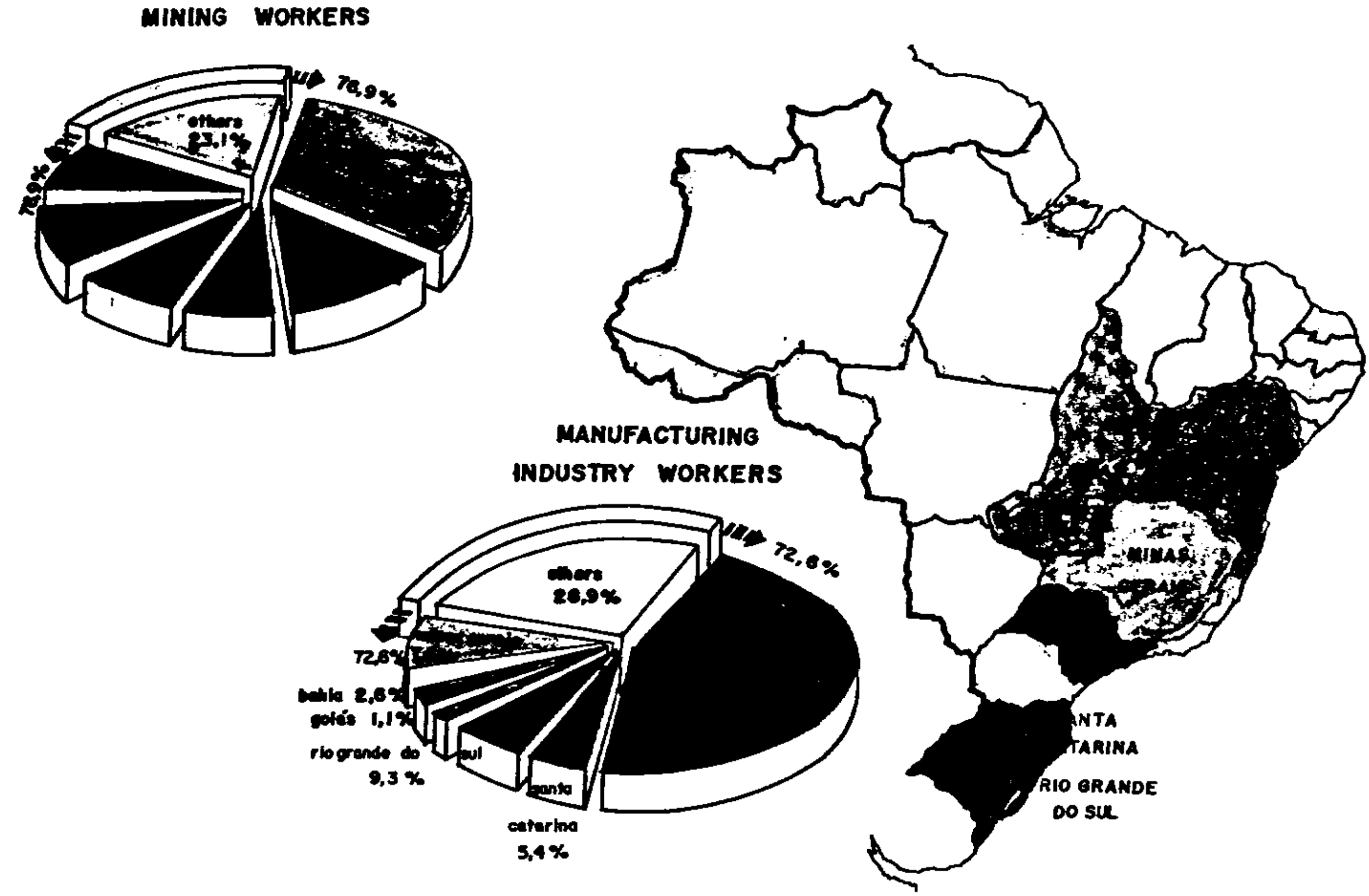

Figure 2

glass industry, foundries, refractories, abrasives, asbestos cement and friction materials is 10.000. 3

Posters and folders were also prepared, as well as technicians from FUNDACENTRO's Regional Unities and from the Ministry of Labor were trained to collect data.

The tabulated data wil define the measures to be taken in the next steps, and the information obtained will be widely spread around the community.

In step II, the identification and the evaluation of workers exposure to the hazards in the workplaces and of the effects on their health will be carried out by means of training courses, characterization of workers exposure, and diffusion of the results.

Training courses wil be promoted for multiplier agents (governmental and private enterprises professionals) aiming at:

a) enabling technicians for evaluating and controlling airborne dust, through recognition, sampling strategies, sample collection and analysis, and control measures;

b) giving credential to support laboratories and standardizing the analytical methodologies of environmental and biological samples by X-Ray diffractometry, gravimetry and microscopy;

c) training medical teams for pneumoconiosis epidemiology and clinic, comprising radiological classification, pulmonary function evaluation and field work methodology.

The characterization of dust exposure will be made through the joint analysis of environmental and medical data obtained during the visits that the specialized teams wil make to the previously selected industries, where they will collect airborne dust samples and will make radiological examinations of the exposed workers, following a methodology developed by FUNDACENTRO together with the Secretaria de Segurança e Medicina do Trabalho (Occupational Safety and Medicine Bureau) of the Ministry of Labor.

In step III, the workers exposure to pneumoconiotic dust and the incidence of pneumoconiosis wil be decreased through educative and informative programs, inspection measures, establishment of specialized centers, and improvement of the current legislation. Guidebooks on hazard awareness and on hazard control measures for workers and employers will be prepared based on data obtained in steps I and II. For spreading out information related to pneumoconiosis prevention, posters and folders will be distributed, and seminars and symposia will be held. Thus an intense inspection by the Ministry of Labor of the most hazardous industries, ac

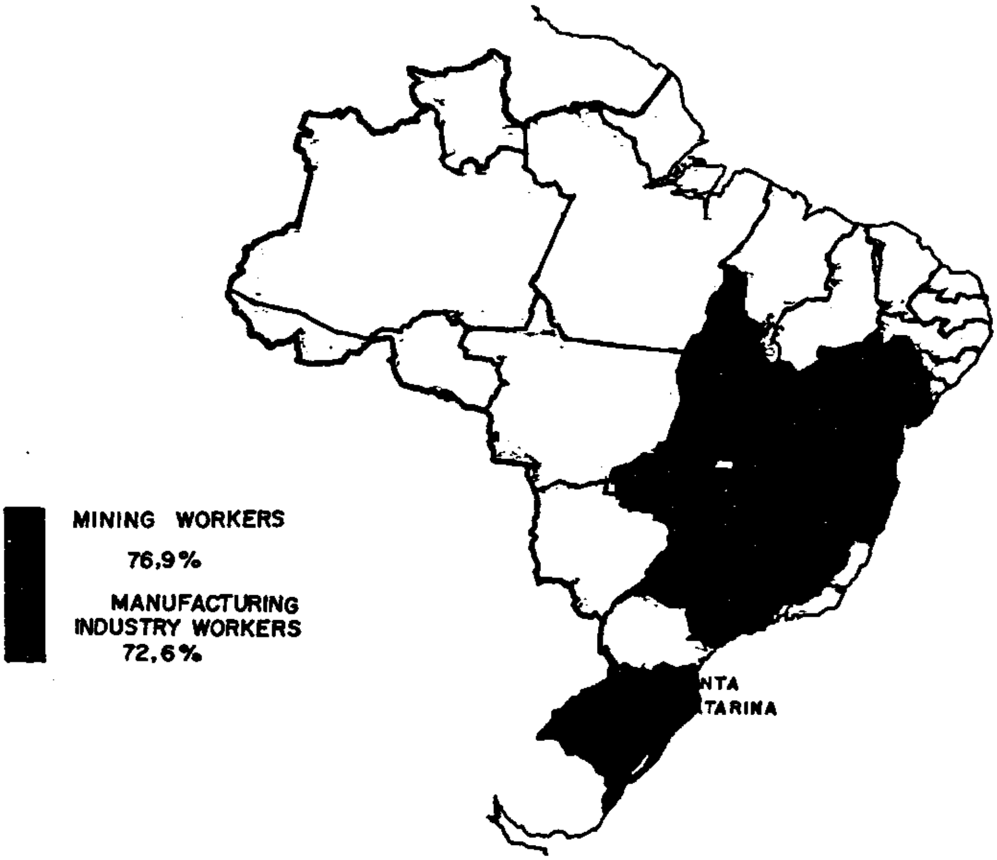

Figure 3. Map of pilot plan.

cording to data obtained in steps I and II, will be possible and efficient.

Additionally, specialized centers for environmental and medical control and evaluation will be established. Its quality will be controlled by National Reference Laboratories of Analytical Hygiene and Radiology being installed at FUNDACENTRO's National Technical Center.

A continuous review and improvement of the Brazi ian legislation wil be emphasized aiming at the effective protection of workers and the enforcement of periodical data supply on the industries in order to keep updated data on production processes and on medical and environmental evaluation.

Specific programs for pneumoconiosis epidemiological surveillance wil also be developed by the Ministry of Health together with the Ministry of Labor in order to evaluate the measures. This will also make possible the relationship between exposure and disease, the study on the respiratory symptoms prevalence of the exposed population, and the technical analysis of pneumoconiosis early detection.

Teams specialized in diagnosis, treatment, mitigation of pneumoconiosis and in professional rehabilitation will carry out the secondary and tertiary measures.

The program will be nationwidely coordinated by engineers and physicians of FUNDACENTRO's National Technical Center and the Secretaria de Segurança e Medicina do Trabalho (Occupational Safety and Medicine Bureau) of the Ministry of Labor and by representatives of the states involved. This coordination team is in charge of the elaboration, follow-up and evaluation of the measures.

CURRENT STATUS

A team has been preparing the material needed to support step 1 measures since 1987 second half.

An administrative questionnaire was prepared for registering the sources where exposure to pneumoconiotic dust can occur. It will be utilized to collect data on working hours, on the number of workers (number of men, women and underage workers), on medical attendance, on the number of trained technicians in occupational safety, hygiene and medicine, on the number of pneumoconiosis cases; on environmental monitoring, on medical examinations for the control of dust exposure, and on training courses. Through this questionnaire information on the specification and quantity of materials employed in the production wil be also known.

These questionnaires were on trial in a hundred industries in the state of São Paulo, and it will be applied in the states involved in the program next September.

Another questionnaire was prepared for collecting data on the operations of industries which generate pneumoconiotic dust.

In order to attain this goal; small, medium and large-sized industries were visited. Based on these data a form was made so as to obtain information on the type of operation carried out in each industry, on the number of equipment used in each type of operation, and on the control measures (starting with the receiving of the raw material and ending with the finished product).

As cleanup is of utmost importance, we also try to know how it is done inside the industries.

In order to obtain the cooperation of workers and employers, posters and folders of the program are being sent to Labor Unions and to Trade Associations.

A previous qualitative analysis of the raw material used in the industries, to detect the presence of crystallized free silica, is being carried out so that priorities may be established after the tabulation of data obtained through the questionnaires.

Simultaneously, airborne dust measurements have been made in different types of industries for quantifying the hazards and making possible the accomplishment of steps II and III.

FINAL COMMENTS

The efficiency of the diffusion, awareness, and training will show a significant increase in the number of pneumoconiotic workers, since to date it is common practice in Brazil to retire workers with occupational respiratory diseases as if they suffered from ordinary diseases. This happens because working conditions at the workplaces and suitable techniques for clinical investigation are totally unknown.

The number of workers retired because of sickness will only start to decrease when the real number of pneumoconiotic workers will be registered. Therefore, this decrease will only be attained in a long period of time.

PREVENTION OF OCCUPATIONAL AND ENVIRONMENTAL LUNG DISEASES

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INTRODUCTION

In the normal lung, there is an extremely rapid turnover of proteins including collagen. This helps in the maintenance of vital function of the gas exchange and need for rapid adopatation in response to injury. Being unusual proximity to the environment, the lung is primary port of entry of noxious gases, fumes and dusts. The same thickness and delicacy that qualify the air-blood barrier for the rapid exchange of oxygen and carbon dioxide reduce its effectiveness as barrier to inhaled microorganisms, allergens, carcinogens, toxic particles and noxious gases. These exposure are normally tolerated by the host. Excess of these substances in the exposure, thus damage to lung not only impair life sustaining process of gaseous exchange but also the defence of organism against microorganisms. In addition, the lung is now recognized as a major site associated with many metabolic activities, the so called non-respiratory functions of the lung.

Like most other organs, the lungs, exhibits only a limited range of responses to damaging agents since the final common path of inflammation and repair involves a fairly limited number of cells. Although nearly 40 different types of cells are found in the lungs.[10] Thus a variety of initiating agents cause damage to host cells in a much more limited number of ways. The uniformity of the final common path response is even more striking when the late healing stage of widespread lung damage is considered. Thus a very wide variety of quite different acute inflammatory reactions, if persistent, will result in a uniform pattern of fibrous scarring. Assessment of hazards associated with inhalation of toxic particles is dependent on a number of factors. The toxic effects are effectively minimized by maintaining the concentration of contaminant below some level which has been deemed unlikely to cause detectable biological damage in people exposed over a long period. Besides, there are other factors that are not directly related to chemical properties that make a substance toxic.

In fact, lung diseases due to exposure of dusts are the most serious among occupational and environmental diseases. Dusts of free silica such as quartz and silicates, e.g. asbestos, talc and mica are known to produce diverse toxic effects which are very well documented.[5] However, inspite of several theories and a large number of experimental and clinical studies the exact molecular mechanism responsible for the pathomorphological and physiological lesions is not yet clear. There is considerable evidence pointing out that silicic acid dissolve from the dusts could be pathogenic fact or as postulated in solubility theory of king and its follow up studies.[3] Many theories on fibrogenic action of silica were put forward but real mechanism of fibrogenesis is not yet known.

PRESENT SITUATION

Although industry is spending unprecendented amount of money to protect its employees from all known hazards, today's technological advances are creating problems faster than we can handle them. In India 56 minerals are exploited through 3350 mines mostly comprising coal, iron ore, limestone, bauxite and manganese etc. The mining industry contributed quite a lot to the regional economic development, however, it has caused ecological and environmental damage to the proportions beyond retreval. The chemical industry in India made spectacular progress during last 4 decades. It is now well-established fact that chemicals play a key role in important sector of agriculture, clothing, housing, transport and health. The present societies have become dependent on the benefits of chemicals to an extent that is irreversible. But many of the basic chemicals which are, essential for the production or on great demand are hazardous—toxic to human and the environment.

EXPOSURE, DEPOSITION, CLEARANCE, TRANSLOCATION AND RETENTION

Once released into the environment, the main routes of entry of chemical into the body are through the lung, skin, eyes and gastrointestinal tract. The occurrence of pneumoconioses, neoplasms and infectious diseases resulting from particulate exposures depends on the deposition and clearance of particles in the respiratory tract.

Deposition is the process that determine what fraction of the inspired particulates will be caught in the respiratory tract and thus fail to exit with the expired air. It is likely that all particles deposit after touching a surface, thus the site of initial deposition is the site of contact. Clearance refers to the dynamic processes that physically expel the particulates from respiratory tract. It is the output of particulates previously deposited. Rapid endocytosis of insoluble particles prevents particle penetration through the alveolar epithelia and facilitates alveolar-bronchiolar transport. It has little possibility that macrophages laden with dust can re-enter the alveolar wall, only free particle appear to penetrate. Thus phagocytosis plays an important role in the prevention of the entry of particles into the fixed tissues of the lung.[1] Silica dust which is cytotoxic has been found to be translocated in the tracheobronchial lymph nodes at a greater rate than the mica dust.[6,9] However, translocation of chemicals or dusts from lungs to lymph nodes may produce other serious effects and sequalae besides fibrotic replacement of nodal tissue could follow the increased accumulation of inhaled chemical substances in the lymph node. The actual amount of substance in the respiratory tract at any time is called the retention. When the exposure is continuous, the equilibrium concentration (achieved when the clearance rate matches the deposition rate) is also retention. When the accidental or sudden massive exposure of chemical occurs as in case of chemical accidents or disasters, the equilibrium between the deposition and clearance is not operative and retention is maximum in comparison to that of normal working conditions. In contrast as in the case of asbestos exposures, a dose too small to produce fibrosis i.e. asbestosis, may lead to lung cancer. A dose large enough to produce asbestosis may cause malignance if the worker does not die first from the pneumoconiosis. Recently the events which were naturally occurring or industrial related in which the release of toxic fumes or gas had occurred, the main route of entry of excess toxic substances is through inhalation (Figure 1). The pathological and physiological state of the individual may

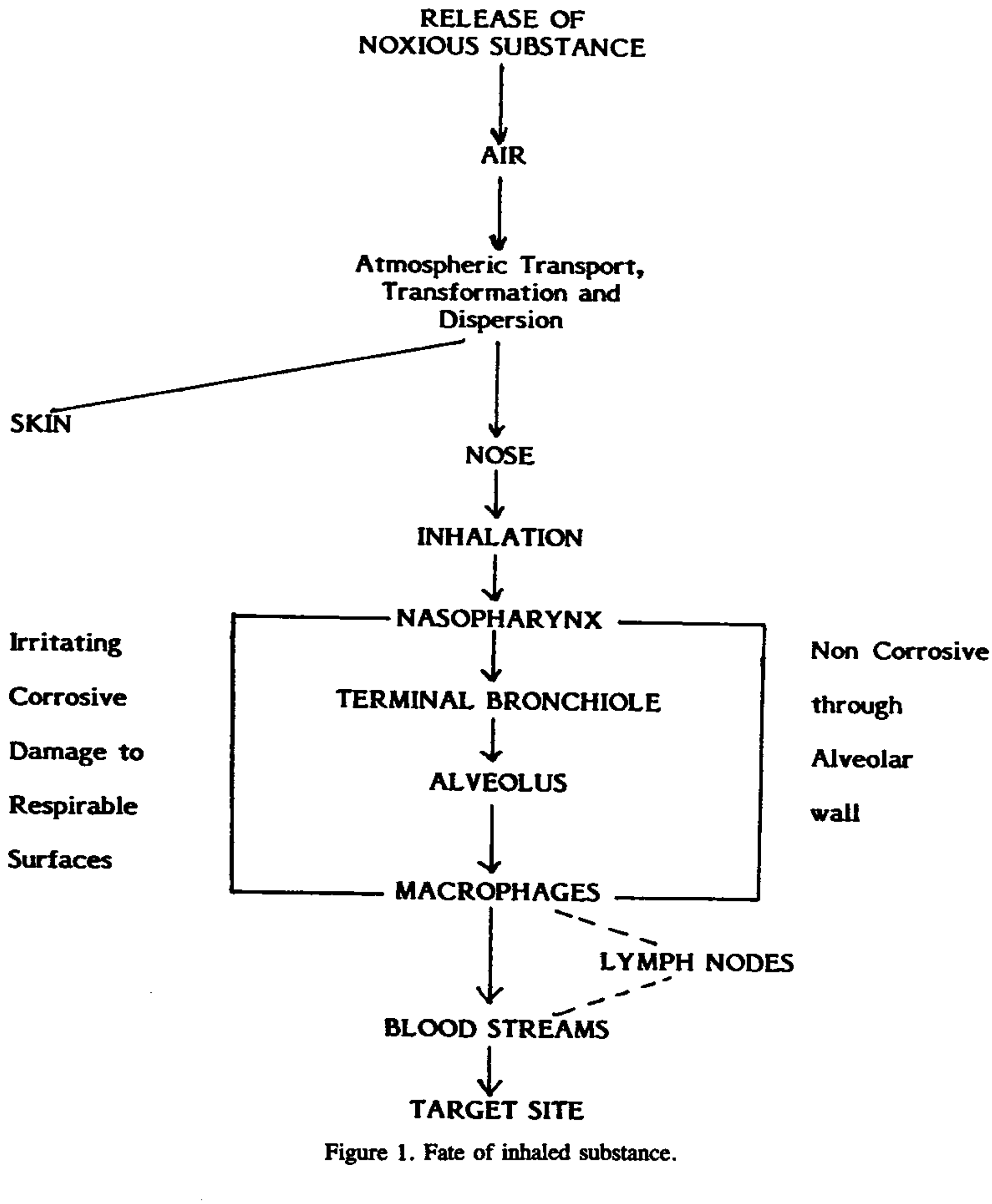

Figure 1. Fate of inhaled substance.

play a major role in biological response after exposure to dusts or chemicals.

PATHOLOGICAL STATES

Prolong inhalation of dust over an extended period of time can produce in certain individuals a respiratory disorders known as coal worker's pneumoconiosis, silicosis, asbestosis and silicatosis. Simple pathological states which are referred as simple silicosis or simple pneumoconiosis in coalworkers which are uncomplicated by any other factor and thus refers to the essential manifestation of the disease. Occupational diseases are associated with complex webs of causations and attributed to both environmental and genetic factors. The industrial workers are liable to all other diseases which affects man. Hence, the other factors such as age, sex, reproductive status, genetic make up, nutritional status, pre-existing disease states and status of immune system influence the disease process and a composite picture comes as clusters of diseases or symptoms. In the case of exposure to chemicals such as Toluene disocyanate (TDI) which affects various parts of the respiratory system. Sometimes it affects the nose and throat, sometimes the bronchial tube and/or the lung. The different pathological states may occur at different exposure level, if exposures are sufficient may affect growth and development, host susceptibility and pre-pathological changes. In case of massive exposure the terminal effect may be progressive fibrosis and mortality (Figure 2).

PREVENTION AND TREATMENT

The search that begun in the beginning of the century, the treatment of silicosis or asbestosis continues unabated to this date in what surely is one f the longest uninterrupted lines of unfulfilled inquiry in Pneumoconiosis Research. It is generally agreed that the dust must be suppressed at the point of origin. If all the preventive measures be introduced then there should not be pneumoconiosis but it is not possible in practice. We can reduce the number of fibres or particles (0.1 μm and greater) per unit area but the predominance of smaller submicroscopic dust particle may modify the type of disease. As electronmicroscopic analysis of isolated lung dust of asbestos exposed and nonexposed individuals revealed high fibre counts. The highest fibre counts were found in individuals exposed to asbestos and mixed dust.[11] At present there is no methods available to specifically interfere with the deposition of collagen in the injured organ. It seems that once the fibrogenic cell triggered by the message to produce more collagen it is already too late for any pharmacological interfere. While the progression of fibrosis might be halted, the actual removal of fibrosis is highly improbable. It is unlikely that alveoli in which fibrosis occur will ever return to normal. Although in the past various substances were tried to prevent silicosis such as Aluminum therapy and lately by the antisilicotic drug Polyvinylpyridine-N-Oxide (PVNO). The therapeutic and preventive effect of Tetrandine—an alkaloid of bisbenzyl isoquinoline (*Stephania*

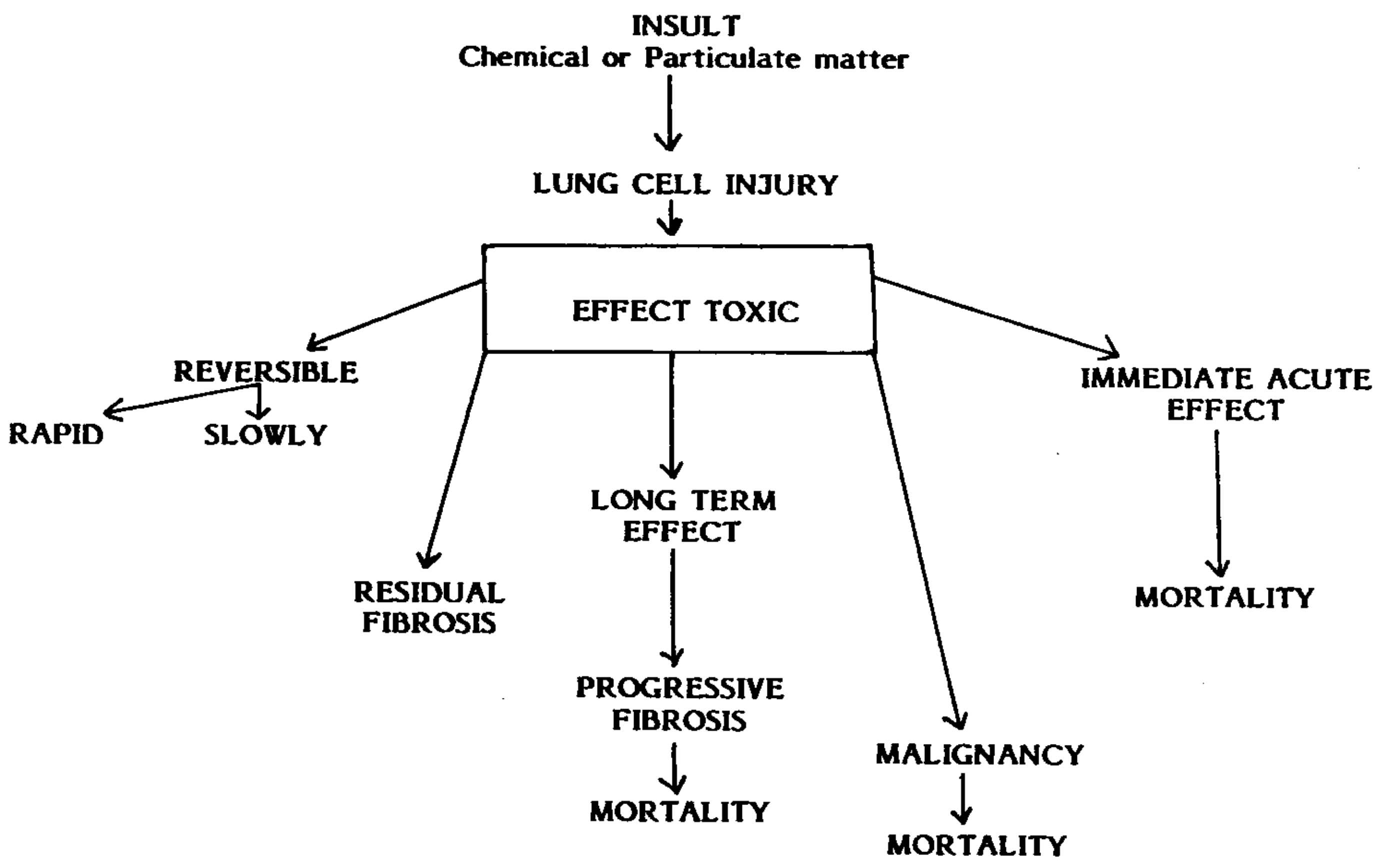

Figure 2. Injury to respiratory system due to exposure.

tetranda S. moor) in experimental silicosis in rats and monkeys as well as marked improvement in symptoms and chest X-ray of human silicotics.[2] Certain toxic effect of tetrandine on long term treatment were found in the form of degeneration and necrosis of cells of liver and kidney. Earlier, several experimental approaches have been attempted for the treatment of pulmonary dust diseases with only partial success using different types of aerosol therapy, hormonal therapy, vitamin therapy and other substances including dietetic factors.[12]

The animal experimentation conducted with various substances when introduced by intratracheal injection, massive pulmonary lesions may be produced, whereas exposing animals to same types of substance by inhalation, no pulmonary damage was found. The impairment in the equilibrium between deposition and clearance of dust particle may be the main source of retention in the lung and ultimately leading to respiratory disorder. We conducted some studies earlier to explore and verify the role of nutritive substance, on the pathogenesis of coal dust induced lung disorders in rats. The effect of Indian jaggery, where many microingredients play some protective role, firstly, by enhancing the physiological pathway of dust clearance and secondly on release of biologically active toxic substances. Naturally when the status of physiological pathway of clearance of host is enhanced then dust larger and/or submicroscopic particles may be expelled during course of exposure of dust through nasopharyngeal clearance mechanism. It has also some effect on the development of fibrosis and deposition of collagen in the lungs. Moreover, the transportation of dust from lungs to tracheobronchial lymph nodes were also altered and produced less fibrogenic lesions in the lymph nodes.

Our earlier studies[7,8] suggested a strong potential of jaggery as protective agent in coal induced lesions in the rat while regular consumption of jaggery is said to confer symptomatic relief in industrial and mine workers and jaggery is therefore routinely provided to workers in most of mining and industrial establishments in India. Moreover, in the case of exposure to gases and fumes only symptomatic treatment is provided. Even in case of long term effect of exposure of gases or fumes the treatment is available on the basis of symptoms only. The antibiotics have certainly saves many lives due to prevention of pneumonia. The better chemotherapy for tuberculosis which complicates many pulmonary disorders are now under control. Simple pneumoconiosis if not prevented may lead to more complicated disease pattern or neoplasia after prolong exposure.

CONCLUSIONS

1. Pulmonary fibrosis and lung cancer are severe and crippling disease, the prevention of the disease must be done by all possible engineering methods.

2. Animal experimental work and epidemiological studies in industries have led to identification of causative factor(s) but mechanism by which effects are produced are not known.

3. More detailed studies on the (a) mechanism of clearance of dust particles (b) enhancement of clearance (c) substances which can reduce the biological effect of dust on retention in the lung and (d) substance or drug which can prevent the fibrotic lesions, are required. Greater thoughts should be given to these steps to minimize the disease process. Care should be taken to ensure the best possible nutritional status and to treat active infections in industrial workers.

4. Lot more is needed to be done in the prevention of occupational and environmental lung diseases.

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PRECAUTIONARY MEDICAL EXAMINATIONS FOR EMPLOYEES EXPOSED BY QUARTZ FINE DUST IN THE FEDERAL REPUBLIC OF GERMANY

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ABSTRACT

In the Federal Republic of Germany, all employees exposed to quartz fine dust at the work station have to be examined on a regular basis by specially certified physicians. Continuation of employment depends on lack of medical objections based on these examinations, which are organized, paid for, and documented by the employer.

For several decades the STEINBRUCHS-BERUFSGENOSSENSCHAFT—the accident insurance institute for quarries—has been in charge of scheduling those medical examinations and keeping records of their results, including X-ray examinations. Hence, for all employees within the responsibility of the STEINBRUCHS-BERUFSGENOSSENSCHAFT, complete and up to date medical history information is available in case of a diagnosed disease.

Moreover, we have started in 1987 to keep records on the actual level of quartz fine dust exposures encountered by each employee in connection with individual job profiles and dust reduction devices. So far, we have accumulated data for about 20,000 employees. These data provide a basis for the physicians to probe the feasibility of and compliance with currently defined quartz fine dust concentration limits in the Federal Republic of Germany.

See Table of Contents, Part II, for Paper.

A METHODOLOGICAL PROBLEM IN INVESTIGATION OF PNEUMOCONIOSIS EPIDEMIOLOGY

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Pneumoconiosis epidemiology has brought to more and more people's attention. A problem frequently faced in statistical analysis to determine the significance of incidence reduction is the paucity of population data for exposure, as met by Hill in his investigation on chromicim chemical manufacture. Under the enlightenment of "Probability window analysis," author advanced a method of contrast analysis combining "the calendar year of beginning exposure" and "the exposure standing up to diagnosis"—the length of exposure years from beginning exposure to the date of diagnosis of pneumoconiosis which is abbreviated "exposurestanding contrast analysis." It proved that the method had certain significance in analyzing effects of dust prevention, evaluating dust harmfulness and handling health surveillance.

METHOD

According to the following conditions, selected plants A and B from the data of Liaoning Provincial Penumoconiosis Epidemiology Investigation as observation targets,

1. Time record was certain before and after a major change of dust prevention.
2. There were systematic data on health examination and environmental survey.
3. There were complete records of pneumoconiosis cases.

Then, draw "exposure-standing contrast" figures according to the following method:

1. On the common standard lattice paper, draw an abscissa and an ordinate which show "the calendar year of beginning exposure" and "the exposure standing up to diagnosis", respectively.
2. According to the two parameters mentioned above. Each pneumoconiosis case is plotted on the figures.

Contrast Method

Figure 1 shows the contrast between two periods. Each observation period included 20 years.

1. Draw three erect lines A, B and C upward from 1945, 1965 and 1985 on the abscissa.
2. Drow two oblique lines toward ordinate from 1965 and 1985 which intersect the lines A, B. Thus two triangular windows with equal size are drawn.
3. Count the number of pneumoconiosis cases in the triangular windows, then, do statistical test by binomial probability distribution.

Figure 2 shows the contrast among many periods including 5 years.

1. On the absicissa, from 1945, 1950, 1955, 1960, 1965, 1970, 1975, draw erect lines A, B, C, D, E, F, G, and I upward.
2. From 1965, 1975, and 1980 draw oblique line toward A,B,C, D, and E. Thus, five triangular windows with equal size are drawn.
3. Count the number of pneumoconiosis cases in the trapezoidal windows and do statistical test to avoid recounting to these same cases.

RESULTS

The history of dust prevention was divided into four periods in plants A and B:

- 1945—period of no dust prevention.
- 1950—period of poor dust prevention.
- 1955—period of wet drill and closed ventilation.
- 1960—period of comprehensive dust prevention.

Figures 1–4 provide plots for each pneumoconiosis cases in plants A and B by "calendar year of beginning exposure" versus "exposure standing up to diagnosis."

DISCUSSION

In Figure 1, 3, the left triangular windows contain pneumoconiosis cases who were first employed between 1945 and 1965. There were a total of 320 cases in plant A and 291 in plant B. The right triangle contains cases who were first employed between 1965 and 1985, no cases in plant A and 7 in plant B. The decline in cases before and after comprehensive dust prevention in 1965 is statistically significant ($p < 0.01$).

In Figure 2, 4, the equal sized windows contain cases who entered the plants A and B in the period of 1945–1959, 1950–1954, 1955–1959, 1960–1964, 1965–1969, 1970–1974, 1975–1979, respectively.

The number of reported pnuemoconiosis cases falling within the windows are 140, 182, 14, 1, 0, 0 in plant A and 216, 196, 30, 3, 4, 0 in plant B, respectively.

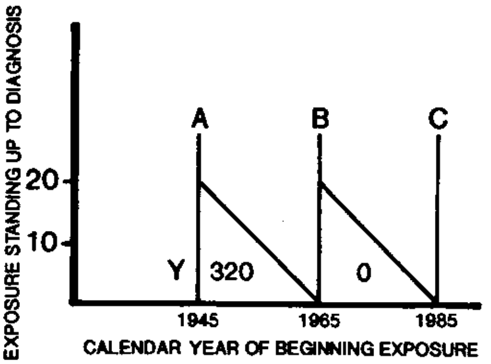

Figure 1. A comparison of pneumoconiosis incidence in equal size observational windows before and after a major dust prevention change in 1965 in A plant.

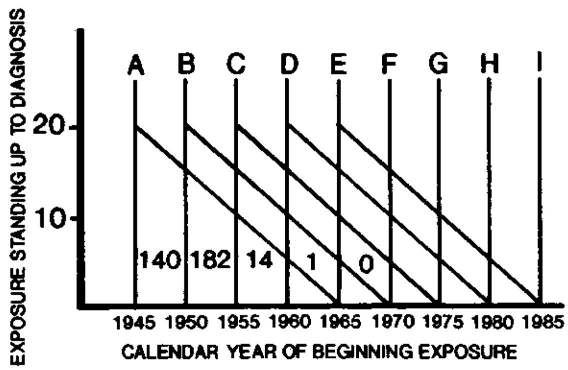

Figure 2. A comparison of pneumoconiosis incidence in equal sized observational windows before, between, and after major dust prevention change in 1960–1965 in A plant.

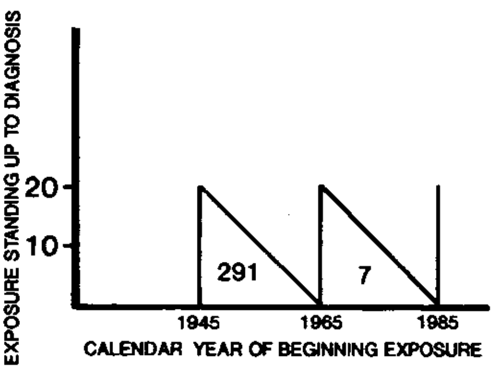

Figure 3. A comparison of pneumoconiosis incidence in equal sized observational window before and after a major dust prevention change in 1965 in B mine.

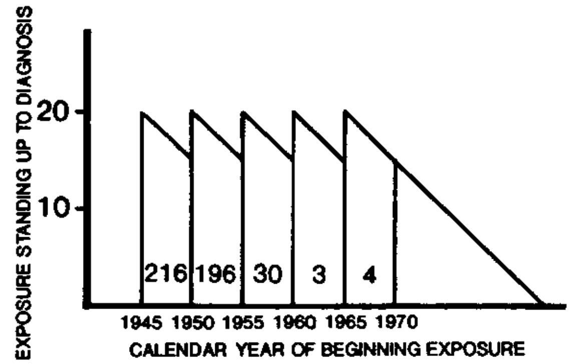

Figure 4. A comparison of pneumoconiosis incidence in equal sized observational windows before, between, and after major dust prevention change in 1960–1965 in B mine.

The results show that dust prevention plays an important role in reducing pnuemoconiosis incidence. The advantage of the method of "exposure-standing contrast analysis" is to be able to assess the probability that a change in the number of cases may have occurred at chosen point in time in the absence of data on exposed population.

When comparing the incidence according to type of works and work standing, it used to be difficult to deal with the following two problem,

1. The calculation was difficult when dividing standing into different groups after having divided types of work, because the divided layer were too many to have even distribution of cases.

2. When calculating the years of standing, it was confounded by the factor of different year of beginning exposure, so that the results might be false and misunderstood. For example, the duration of exposure may be the same of 10 year but the effect of 10 years exposure 20 years ago is different from that of latest 10 years. That is because the environmental and hygienic situation has been changing greatly in recent 20 years.

The method of "exposure-standing contrast analysis" is to do contrast analysis between two periods by combining two parameters of "year of beginning exposure" and "exposure standing up to diagnosis," so as to get a clearer picture that when (in what calendar year) the worker was exposed to dust and how long (years) the workers' standing was since then.

The concept has a important significance not only in assessing the preventing effects but also understanding the harmfulness to workers caused by dust pollution at workplace in different period. Hence, it has a reference value to carry out health surveillance and administration, analysis the results of body's examination and evaluate the trend of pneumoconiosis incidence change.

BRIEF SUMMARY

It is proved through study that the method of "exposure-standing contrast analysis'' can be used to assess probability that a change in the number of cases may have occurred at a chosen point in time. In the absence of data on exposed population and proved the basis to evaluate preventing effects, medical surveillance, health guardianship and administration conditions.

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A COMPREHENSIVE PROGRAM FOR IMPROVED MANAGEMENT OF RESPIRATORY HEALTH

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INTRODUCTION

Morgan has described a medical condition of the lung, of nonsmokers in the industry trade, characterized by chronic cough productive of sputum and accompanied by mild obstruction of the large airways. Since X-rays of the chests of these workers exhibit few change, and therefore little parenchymal involvement of the lung, he termed this entity industrial bronchitis.[1] Other investigators have reported similar findings in studies of workers having long-term exposure to nuisance dusts.[2,3]

In a study of workers exposed to high total dust levels of bauxite and alumina for 20 or more years, Townsend *et al* in a cross-sectional study of pulmonary function test results demonstrated a statistically significant increase in numbers of workers with a forced expiratory volume in one second (FEV_1 of less than 80% of predicted.[4] A separately reported study of changes on chest X-ray of these high-dust-exposed workers compared to others with little exposure revealed only minimal nonsignificant X-ray changes.[5]

Because of this evidence of a decrement in FEV_1 of workers exposed to high levels of dust for twenty or more years, Alcoa's medical staff decided to plan and implement a standardized program for pulmonary surveillance at domestic locations.[6]

GENERAL DESCRIPTION OF ALCOA'S PULMONARY SURVEILLANCE PROGRAM

The goal of Alcoa's program for management of respiratory health is prevention of work-related lung impairment. We have identified two objectives which must be met in order to attain this goal. First, we must improve management of the multiple activities which are necessary for providing adequate respiratory protection, and secondly we must establish a mechanism to reevaluate continually the overall effectiveness of our efforts.

The major activities which must be managed for an effective program of respiratory protection are:

- Identification of hazardous exposures by air sampling;
- Education of employees about the respiratory hazards at work and the measures necessary for adequate protection;
- Provision of respiratory protection where indicated;
- Training of technicians to perform standardized testing of pulmonary function;

Pulmonary function testing of employees exposed to hazardous
materials;

- Identification of employees with lung function loss meeting some set of criteria;
- Medical referral of employees with confirmed functional loss for further diagnostic evaluation; and
- Modification of environmental controls to reduce health risks.

The resources we have developed for evaluating the overall effectiveness of our program for respiratory surveillance are:

- Creation of computer software to provide automatic storage of and access to data generated by spirometric testing;
- Development of criteria incorporated in the software for screening of spirometric test results; and
- Periodic analysis of data to determine the adequacy of the

surveillance program.

PULMONARY SURVEILLANCE SYSTEM

We have created a computer-based system to support functions in the plant medical departments as well as at the corporate medical level. The system is supported by a personal computer (Compaq 386) with a printer in each plant medical department and a mainframe computer in Pittsburgh. The plant-based computer interfaces with a spirometer and is programmed with algorithms to analyze and screen the results of each test as it is performed. If the medical staff wishes, at the end of a test, a report may be provided to the employee. The file of the Compaq 386 is sufficiently large to accommodate these functions as well as previous test results for each employee at a plant with about 1500 employees.

The plant-based computer is also programmed to permit periodic uploading of all interim test results to a Pittsburgh-based mainframe file.

The mainframe computer file contains test results for all employees at domestic locations, and the corporate medical staff has access to this file for periodic assessment of the timeliness of testing at each plant as well as for determining the incidence of functional decrements experienced by employees exposed to irritating dusts.

The mainframe computer software also has a scheduling function to identify a future date for the next scheduled test for each employee. This new schedule for testing is downloaded to the plant personal computer. In this process the mainframe computer also downloads all job or demographic changes derived from another system maintained in Pittsburgh.

Criteria for Screening and Analysis of Spirometric Test Results

In Alcoa, pulmonary function testing is performed as a part of preplacement evaluations, non-occupational periodical medical evaluations, and periodic medical screening for hazardous work exposures.

Medical and industrial hygiene personnel have identified all plant materials which may be hazardous to the lungs. Arbitrarily we have identified an action level for triggering a medical exam. An action level is an exposure exceeding one-half the threshold limit value established by the American Conference of Governmental Industrial Hygienists.[7] Employees having such exposures have pulmonary function tests yearly. If test results are less than expected, the employee is retested in three months.

From Knudson's prediction equations[8] the plant personal computer has been programmed to calculate the predicted FEV_1 and the predicted forced vital capacity (FVC) based on the individual's age, sex, and height. Predicted values are adjusted for race. After corrections for BTPS the computer selects: the maximal FEV_1 and calculates a percent of predicted FEV_1 ; the maximal FVC and calculates a percent of predicted FVC; the maximal FEV_1 and calculates a percent of maximal FVC.

The criteria selected for the classification of respiratory impairment is consistent with the American Medical Association's guidelines for determination of respiratory impairment.[9] These criteria are: for normal function, a percent of predicted FEV_1 or FVC of 80 or better; for mild impairment, percent of predicted FEV_1 or FVC of less than 80 but 60 percent or better; and for moderate to severe impairment, a percent of predicted FEV_1 or FVC less than 60.

From the reports available, there appears to be considerable interest in developing sophisticated methods in the future for analyzing longitudinal pulmonary function data.[10,11,12] However, from a review of the recent literature there is insufficient information to support establishment with confidence of criteria for expected annual decrements in pulmonary function test results for an aging population.

In the absence of supporting information we have established arbitrary criteria to define significant loss of lung function over time (Table I). Because of the widely recognized variability in pulmonary function test results over time a worker, for his loss to be significant, must demonstrate a

Table I

Criteria for Defining Significant Lung Function Loss

Interim Between Tests	Decrement in FEV_1 or FVC
0 - 1 Years	> 300 ML
0 - 2 Years	> 350 ML
0 - 3 Years	> 400 ML
0 - 4 Years	> 450 ML
0 - 5 Years	> 500 ML
0 - 6 Years	> 550 ML
0 - 7 Years	> 600 ML
0 - 8 Years	> 650 ML
0 - 9 Years	> 700 ML
0 - 10 Years	> 750 ML

decrement in FEV_1 or FVC greater than 250 ml plus a yearly decrement 50 ml. (See Table I.)

Medical referral for diagnostic testing is dependent on identification of employees exhibiting a significant loss in pulmonary function on successive tests. An employee with normal lung function (FEV_1 or FVC $\geq$80% of predicted) will be referred for medical evaluation after he exhibits a significant loss on three successive tests or his test results indicate a change in status from normal to mild impairment (FEV_1 or FVC <80% but $\geq$60% of predicted).

A worker with mild impairment will be medically referred if he exhibits a significant loss on two successive tests or if his most recent test indicates a change in status from mild to moderate impairment (FEV_1 or FVC <60% of predicted) his lung function becomes moderately impaired. A worker with existing moderate impairment will have a medical referral after exhibiting a significant loss on one test.

All plant medical technicians have received training in the conduct of standardized pulmonary function testing. At the end of August, 1988, computer-based testing is being done at two locations, and the corporate medical staff is preparing a schedule to complete implementation of the program at Alcoa's domestic locations over the next eight months. We think having a system to provide timely information about changes in lung function will permit us to achieve a high level of respiratory protection for Alcoans exposed to respiratory hazards.

Hazardous materials at all plants have been identified. Industrial hygienists have completed work on an employee educational package which will be distributed to all plants in the Fourth Quarter, 1988. We anticipate that the full program will be implemented at all domestic plants by mid-1989.

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