Surveillance for Respiratory Hazards

Introduction

Occupational respiratory diseases are an important cause of disability, days lost from employment, and death (1, 2). Because of this, there has been concern for the need, expectations for the provisions, and demands for the initiation of occupational health surveillance programs by society, by employed persons, and by governmental agencies. While early programs were limited in scope, present emphasis has enlarged the components and services of an occupational health program. Furthermore, an effective program requires the skills of various professionals who are trained or experienced in such disciplines as medicine, industrial hygiene, toxicology, epidemiology/biostatistics, nursing, and safety engineering (2). An organization structure is necessary to assure that the top echelons of management are aware and informed of all significant occupational health concerns so that appropriate corrective action can be taken when necessary. At the same time, procedures for preserving employee confidentiality must be administered. Records that are developed should include medical and industrial hygiene information and data necessary for epidemiologic review, which are pertinent to workplace exposures.

This document will list and discuss those components and services that are considered a necessary or essential part of an occupational pulmonary surveillance program. By surveillance is meant the continuing scrutiny of all aspects involved in the occurrence and/or development of occupational pulmonary disease that are pertinent to effective control of disease (3). Surveillance includes collection, collation, and analysis of relevant data, as well as reporting to persons responsible for controlling hazards in the workplace.

This paper was prepared by the Task Group on Surveillance for Respiratory Hazards in the Occupational Setting. This task group is one component of the ATS Task Force on Screening that was appointed by the ATS Executive Committee in November 1979. The purpose of the paper is to present guidelines for occupational screening programs based on a review of the current state of the art.

The paper is presented here for membership review. Please send your comments to the American Thoracic Society, 1740 Broadway, New York, NY 10019 by April 1, 1982.

Components of an occupational respiratory disease surveillance program are listed in table 1. It is apparent that of the components listed, only one relates to medical evaluation of the health status of employees. This can be accomplished by using appropriate screening tests. Screening means the presumptive identification of unrecognized disease or defect by the application of tests, examinations, or other procedures that can be applied rapidly to sort out apparently well persons with probable disease from those probably without disease. A screening test is not intended to be diagnostic. Persons with positive or suspicious findings must be referred for diagnosis and necessary treatment (4).

TABLE 1

COMPONENTS OF OCCUPATIONAL RESPIRATORY DISEASE SURVEILLANCE PROGRAM

Regular evaluation of employee health status
Education of employees
Assist management
Proper maintenance of medical records
Employee evaluation for respiratory protective devices
Initiation/interpretation of government regulations
Insure proper training and performance of personnel and surveillance equipment
Epidemiologic evaluation of workplace/employees
Industrial hygiene evaluation of work environment

Principles Underlying Screening Programs

Screening may have one of several aims (5). It may be undertaken as part of an epidemiologic survey to determine the frequency or natural history of a condition (i.e., Framingham study of coronary heart disease), prevention of a contagious disease and protection of the public's health (i.e., mass chest X-rays for detecting tuberculosis), or the detection of disease, or precursors of disease, as a guide to the medical care of individuals (i.e., occupational respiratory screening programs).

In undertaking an occupational respiratory screening program, the presumption is made that not only are the screening methods reliable, but treatment or remedy is possible and will be made available to those who require it. In addition, it is essential to insure that the screening will make better use of limited resources than competing medical measures (5). The implication of these requirements for screening procedures are reflected in the following list of principles (6, 7):

1. The condition sought should be an important health problem.
2. There should be an accepted treatment for individuals with recognized disease.
3. Facilities for diagnosis and treatment should be available.
4. There should be a recognizable latent or early symptomatic stage.
5. The natural history of the condition, including development from latent to declared disease, should be adequately understood or studied as a result of the findings.
6. There should be a suitable screening test or examination for detecting the disease at the latent or early stage.
7. The test should be acceptable to the population.
8. There should be previously agreed upon criteria or policy to identify and classify those with injury or disease and those to treat as patients.
9. Further diagnostic study and/or treatment (if known) of patient revealed by the screening programs should be made available.
10. The cost of case-finding, including diagnosis and treatment of patients diagnosed, should be economically balanced in relation to possible expenditure on medical care as a whole.
11. Caution should be exercised to assure that the benefits accruing to the true positives outweigh the possible harm which might be done to those falsely identified as a positive diagnosis.
12. Case-finding should be a continuous process – not a "once and for all" project.

Purposes for Conducting Surveillance in Industry

The primary reasons for initiating and conducting surveillance programs in industry are:

1. to detect respiratory impairment of disease prior to placement;
2. to determine the nature and extent of both occupationally related and naturally occurring respiratory diseases in the workforce;
3. to conduct epidemiologic studies related to hazards known or thought to be present in the workplace;
4. to produce data which, when considered along with other evidence, will help to determine standards for limiting exposures in order to prevent injury or disease.

Baseline and ongoing surveillance in industry should be programmed to proceed in a step-wise fashion. (See table 2.)

Screening Tests To Use in A Surveillance Program

Standardized procedures have been developed for study of large population groups

in the Occupational Setting

TABLE 2

PLAN FOR ONGOING SURVEILLANCE

Level	Site	Employees
I. No hazard thought to be present	I. Catalogue and review of materials and processes	I. (a) Questionnaires (b) Simple PFT (1) FVC (2) FEV-1 (c) Baseline CXR
II. Suspicion of hazard present	II. Above plus: Area and personal monitoring by industrial hygienist	II. Above plus: "Hands-on" physical examination and review by a physician to consider further tests
III. Known hazard present	III. Above plus: (a) administrative controls, (b) engineering changes, (c) individual protective equipment	III. Above plus: Special testing based on hazard present

(8). Performed initially or cross sectionally, screening studies may determine prevalence of symptoms, status of pulmonary function, and similar situations at one point in time. Repeated, using the same population at a later time, they serve as prospective or longitudinal studies and can then determine incidence of disease or give information regarding progression or development of illness. Data derived from screening studies differ from those required for clinical studies, which are diagnostic and directed toward individuals rather than groups.

Abnormalities identified by screening must be confirmed and then referred for diagnostic studies in order to determine their relationship to the work environment and their true significance. The various tests/parameters which may be used in pulmonary screening in an occupational setting include the history, physical examination, spirometry, chest X-ray, and other tests. Some of these have been discussed in detail previously (8).

History and Physical Examination

Employees should have a complete health history taken upon employment. This history will serve as a baseline against which to measure changes occurring during the employment period. The respiratory questionnaire is an important component of this complete health history. In the early 1950's, the basic concepts were developed in England by Fletcher (9). After extensive studies, the Medical Research Council (MRC) accepted a standard questionnaire in 1960, with a revision in 1976. It has been translated into many languages and used world-wide (10). For the United States, the American Thoracic Society (ATS) Committee for Standardization of Epidemiological Methods has published a similar questionnaire (11). For the industrial setting, the ATS questionnaire can be applied appropriately. Three features of the questionnaire are especially important: degree of dyspnea, amount of cough and sputum, and amount of cigarette smoking.

Breathlessness is often the principal manifestation of pulmonary impairment. Causes of dyspnea are complex and still remain poorly understood, and a person's response to questions concerning shortness of breath are variable. These responses may be influenced by factors unrelated to lung disease, such as difficulty of verbal expression, socioeconomic factors, and educational background. These considerations are an important element in dyspnea evaluation. However, for the most part in the industrial setting, the degree of dyspnea can be determined with specific questions. For example, the following descriptions are taken from the MRC and ATS questionnaires (9, 11):

Grade	*Degree*	
0	None	Not troubled with breathlessness except with strenuous exercise.
1	Slight	Troubled by shortness of breath when hurrying on the level or walking up a slight hill.
2	Moderate	Walks slower than people of the same age on the level because of breathlessness or has to stop for breath when walking at own pace on the level.
3	Severe	Stops for breath after walking about 100 yards or after a few minutes on the level.
4	Very severe	Too breathless to leave the house or breathless when dressing or undressing.

The amount of cough should be determined: [1] none or occasionally with colds, [2] mild, an occasional morning cough, [3] moderate, four to six times daily, and [4] severe, morning and throughout the day for three consecutive months or more. Sputum production should be similarly categorized: [1] none, [2] occasional morning sputum, [3] moderate, twice a day, four or more days of the week, [4] severe, morning and throughout the day for three consecutive months or more. Importantly, the duration of cough and sputum should be noted, especially if these symptoms occur at least three consecutive months over two or more years. The answers to these questions can be used to determine the presence of "chronic bronchitis," which is arbitrarily defined as a productive cough for most days for a minimum of three consecutive months for two or more years (12).

Concerning cigarette smoking, subjects should be classified as nonsmokers if they smoke less than 20 packs of cigarettes or 12 ounces of tobacco in a lifetime or less than one cigarette a day for one year. Information from smokers include age started and, if appropriate, stopped smoking. The amount smoked should be categorized as packs per day, e.g., less than one-half, one and one-half and two or more.

Apart from these three important questions, several others are helpful in the industrial setting. The presence of wheezing should be categorized as slight if it occurs only with colds or severe if wheezing is present daily. In selected industrial settings, the occurrence of wheezing or productive cough on Mondays or after returning to work from holidays may be important symptoms related to occupational asthma. The occurrence of hemoptysis, whether slight with blood-streaked sputum or severe, should be recorded.

Information concerning nonpulmonary disease should also be recorded. These include cardiac disorders, hypertension, diabetes, peptic ulcer disease or other gastrointestinal abnormalities, neoplastic disease, renal disease, or rhematologic or neurologic disorders. Type and dosages of required medication should be listed as well. In addition, questions concerning past pulmonary illness should be specifically noted. These include chest illnesses during the previous three years, which have had the subject off work, indoors, at home, or in bed. Specific pulmonary diseases include pneumonia, asthma, bronchitis, emphysema, or tuberculosis. Similar pulmonary diseases occurring in the family should also be listed. There are several other detailed questions concerning symptoms and cigarette use, which are available in the ATS publication (11). These questions should be used according to specific industrial environments.

Bias is an important concern of respiratory questionnaires. For example, observer bias was initially a problem in the 1950's, but this can be minimized by properly training personnel (10). Questionnaire modification is another source of bias with minor altera-

tions in questions concerning symptoms reducing reliability. In industrial surveillance programs, the mode of administration is an important consideration. The early questionnaires were developed for administration by an interview but they have now been adapted for self-completion (11). Fortunately, the self-completed type of questionnaire has not created an additional bias. There has been a high level of agreement between responses to the dyspnea, cough, and phlegm questions of an administered MRC questionnaire and responses of a similarly worded ATS questionnaire that was self-completed (10).

Occupational History

Another essential component is a complete occupational history. For the purpose of surveillance, two sources of work exposure history become important;

1. *Prior Work History* — Occupational exposures that resulted during previous employment wherein the employee is the primary source of information, and further data usually is obtainable only by the employee requesting a release of any available records of prior employers.
2. *Current Employer Work History* — Occupational exposures can often be imputed from personnel records where past and current environmental surveys are linked to job titles for given work areas, where individuals in such areas can be identified for given blocks of time, and where survey data can be reasonably attributed to all identified employees in all time blocks.

From a practical viewpoint, there are reasonable limits that one expects to achieve from both of these sources. From most job applicants one can expect a person to be able to complete an employment form with basic information on job titles, employer's name and address, years of service in each job title, and dates of transfer or termination. By a careful review of such a self-completed employment form, a skilled interviewer can often determine whether or not any prior employers required medical surveillance, whether any inhalation hazards were reported to the employees in the work area, whether any specific exposure controls were evident to persons assigned in the area, and whether the interviewee experienced or reported any occupational respiratory disease conditions during employment in the area. The level of detail and accuracy of such an occupational history by interview probably varies from one job applicant to the next, and certainly as one attempts to retrieve such information over periods of ten or more years prior to the current date, recall becomes less reliable. One should balance the use of this information from the standpoint of a current medical surveillance decision against such reliability questions; hence, when placing a worker with a history of prior work exposures that may have included an occupational respiratory disease risk, the physician should focus primarily on the patient's current respiratory health status and require medical surveillance only where the current job assignment would so indicate. One can defer a final decision on medical surveillance and attempt to retrieve fuller details from prior employers where the level and type of the prior exposures would appear to be more important to the patient's health, especially where the current respiratory health status is abnormal or borderline by routine screening tests.

Each employee should have a reasonably complete job assignment history maintained by his current employer. Such information becomes more useful to the medical staff if specific exposure details are recorded in each medical folder and updated periodically. This seemingly simple ongoing exposure history is more difficult to implement than one would expect; however, one cannot assemble a roster of candidates for medical surveillance without knowing who are transferred in and out of respiratory hazard areas and when. Given information that an employee has been assigned to such an area and that surveillance has been triggered, the sources of environmental data include both independent sources, such as in survey records, and a current exposure history from the employee. Comparisons of such different sources is often helpful, and when one is obtaining a patient history, one can inquire into avocational exposures or moonlight job activities as well.

For purposes of cross-checking, two additional occupational history tools should be used to supplement the chronologic exposure histories:

1. *Specific Agent Questionnaire* — A listing of specific inhalants that are prominent causes of occupational respiratory disease.
2. *Specific Occupational or Industry Group Questionnaire* — A listing of job situations where occupational respiratory disease incidence is generally regarded or suspected to be higher than the average rate.

Physical Examination

The physical examination is important for the detection of finger clubbing, wheezes, and crackles (13, 14). Additional information is also helpful, such as a general description of the patient, presence of cyanosis, or pedal edema, description of the patient's breathing, extent of chest excursion, intensity of breath sounds heard, and results of cardiac, abdominal, neurologic, and joint examinations.

The detailed respiratory questionnaire as well as the physical examination should be performed for pre-employment or preplacement, transfer into hazardous area from previous employment, and transfer out or retirement. Questionnaires for preemployment, transfer in or out, and retirement should be performed by an interviewer whereas the periodic questionnaires may be self-administered.

Spirometry

Spirometry Criteria

Persons employed in hazardous occupational settings should have a spirogram performed. The minimum requirements should be the measurement of FVC and FEV$_1$ (15). Spirometry should be conducted using the techniques, criteria, and instrumentation recommended by the Snowbird Workshop (16). Spirometers have been evaluated for compliance with the Snowbird criteria and results reported for devices available in 1977 (17, 18). As stated by the Snowbird Workshop, "At least 3 acceptable tests are required to ensure maximal effort and cooperation are obtained. . . ." This requirement has subsequently been verified (19). Recent studies (20) have shown that selections of a single "best test" by taking the spirogram with the largest sum of FVC and FEV$_1$ allows all measurements to be made on a single waveform and does not make a significant difference with normal or diseased subjects.

Performance of spirometry is critically dependent on the subject's performance. Technicians should be well-trained, motivated, and able to demonstrate an acceptable performance in the actual situation. The training requirements suggested by CORD and NIOSH are recommended (21, 22).

Results Evaluation

Once the spirometric tests have been performed with appropriate technique, instruments, and technical staff, then the results need to be evaluated (23). Because measure of ventilatory function is dependent on age, height, sex, race, and other factors, all these parameters should be considered in any interpretation. One can evaluate spirometric tests by (1) using the subject as his/her own control, or (2) comparing the subject with a reference or "normal" population. Using the subject as his or her own control gives better sensitivity than comparison with a normal population. The coefficient of variation within a subject is 3% to 6% for FVC, and it is near 14% with a population. Because the normal yearly decrement in ventilation is small (approximately 25 ml/yr for FVC), to detect abnormality the decrement must either be large or the subject must be followed for a long time. Ade-

quate longitudinal studies have not been done; therefore, it is currently necessary to compare a subject's observed values with a reference population.

Normal Values

Prediction equations for determining normal values have been derived by many investigators (24-27). Comparison of the FVC and FEV_1 reference values has recently been reported (28).

The Intermountain Thoracic Society (ITS) has formalized interpretation criteria (29). There has been recent interest in the variability of interpretation (30, 31). Based on the data of Crapo, the suggested lower limit of "normal" is a fixed decrement from the predicted value (e.g., for males FVC = 1.102 liters; FEV_1 = 0.831 liters). The subtraction of just one number for all adult males for FVC is justified because the 95% confidence limit range is so small. Recent reanalysis of the 1971 Morris-Oregon survey data has provided results nearly identical to the study of Crapo and associates (27, 28, 32).

Obstructive lung diseases should be classified by either using the FEV_1/FVC ratio or looking at predicted values.

Chest X-ray

Radiologic surveillance for respiratory hazards in the occupational setting must include consideration of the need, type, and frequency of surveillance, minimal standards for equipment and filming, and the method of interpretation and recording of the information for patient care, record keeping, and epidemiology. Although data have shown that routine surveillance for respiratory disease, specifically tuberculosis and carcinoma, in the asymptomatic population has been nonproductive, routine surveillance in those exposed to a respiratory hazard is essential (33-35).

Recommended surveillance studies of those with known or potential respiratory hazards:

1. Routine chest x-ray, preplacement. This establishes a baseline for those without respiratory disease and will demonstrate some in whom pre-existing disease would preclude exposure.
2. Routine PA screening films at two-to five-year intervals in asymptomatic individuals, depending on specific hazard. Discernible change in the radiograph in those without symptoms or signs of respiratory disease at more frequent intervals (e.g., yearly) is unusual.
3. In the event of a large known exposure, either short term or prolonged, more frequent films may be indicated as determined medically.
4. Symptomatic individuals should be evaluated as determined medically.
5. A lateral film should be obtained only when indicated by findings on the PA film.
6. PA film on job change.

Equipment and Technique Standards

Detection of early radiographic change of pulmonary disease is dependent on good quality radiographs and comparable films from one examination to another. Use of high KV filming technique (120-150), short exposure, grids, proper screen-film combination, and carefully controlled processing techniques are essential to the production of the most consistent and good quality radiographs. Photo-timing adds considerably to consistency from film to film. Details of proper equipment and technique standards have been published (33, 36).

Interpretation

1. All films should be double read, with at least the second reader being a certified *B* reader. The second reader should not be knowledgeable of any clinical factors or respiratory hazard exposure data and films of nonexposed individuals should be submitted along with those exposed, without knowledge of the reader.
2. All films should be interpreted using the most recent ILO Classification System. A narrative report should accompany all positive films. In those cases in which significant discrepancy exists between the interpretation of the two readers, a reader recognized as an expert in radiographs of pneumoconiosis should serve as an arbitrator and give the final interpretation.
3. When possible, comparison films should be submitted with the current film being evaluated.

Employee Education Program

Employee education functions are an integral part of an occupational respiratory disease prevention program. The medical persons charged to assist employers in protecting workers from acute or chronic respiratory health hazards should maintain the confidence and trust of employees exposed to these hazards in order that surveillance and hazard control be effective. The worker educational function should be delegated as a joint responsibility of production, personnel, safety, and medical staff persons. A physician is usually accountable for certifying the accuracy and appropriateness of the health-related information; e.g., the explanation of potential respiratory hazard health effects, early symptoms or signs of injury or illness, recommended medical interventions if suspected overexposures occur, requirements for a medical intervention program, including periodic tests on employees, and procedures for counseling employees on their respiratory health questions. Usually the educational program is carried out by a combination of distributed or posted written material or booklets, plus informal small group counseling sessions.

As indicated above, physicians or nurses may carry out more personal and confidential counseling with individual employees regarding respiratory illnesses or medical test results. When these personal health problems affect the employee's fitness for job assignment, or where reporting an occupational illness or condition is involved, the physician will be obligated to inform the employee of medical-legal issues and to carry out the appropriate notifications of the employer and/or governmental agencies. Likewise, the physician may assist the environmental monitoring and control program by examining a worker so as to determine whether the employee has a personal health condition that would require special job safeguards. Such personal health problems may involve communications with the employee's personal physician; hence, the occupational physician would enter into such communications only with the permission of the employee, usually following a counseling session.

The responsibilities of employee health education for occupational respiratory disease protection, therefore, ranges from publication and dissemination of safe work practices or medical tests to be performed to very confidential counseling on personal medical matters.

General Purpose and Content

It is recommended that workers required to be in a medical surveillance program be afforded an opportunity to participate in an educational program directed to inform the workers of the nature of the agent(s), process(es), and area(s) where occupational respiratory disease hazards are known or suspected in the workplace. Also to be included in the educational program for employees assigned in designated hazard areas are each of the elements of a medical testing program; the primary purpose of this education is to obtain an informed consent for medical testing of all workers at risk. The worker should be advised as to the results of environmental measurements that form the basis for designating the workplace as a respiratory disease hazard area. The workers should also be informed of the recommended work practices to be

used for mitigating the risk, the engineering controls, and any requirements for employee respiratory usage. Finally, employees should receive information on plans for continuing environmental surveys and medical monitoring of all respiratory disease hazard areas requiring surveillance. It is recommended that the education program be conducted on a periodic basis so as to assure the physician directing the medical surveillance program that there is a continued understanding of the environmental and medical measures being taken to protect the respiratory health of the worker.

Three Events that Trigger Education

Where a worker is to be hired for or transferred into a respiratory disease hazard area, the above education requirements should apply, including access to environmental and medical data on groups of persons previously assigned to the work area, and interpretations thereof. Also to be included in the information available prior to a placement decision are any medical restrictions to be placed on the employee using the results of a preplacement examination; these results should be explained to the applicant or transferee. Each employee entering assignment in a respiratory disease hazard area should understand the early signs of an uncontrolled hazard, the basic purposes for monitoring, and the essentials for control.

Where a worker is assigned in a hazard area and an illness or injury occurs, temporary or permanent medical restrictions for the ill or injured worker shall be set by the attending physician. These restrictions shall include an assessment of the physical demands of the job and the environmental exposures in the hazard area. The rationale for these medical restrictions should be discussed with the worker at the time of return to duty.

At the time of transfer out of a respiratory hazard area, or upon termination, the employee should be offered a medical examination. The employee should be advised as to the final medical findings obtained from this examination including those pertaining to the job hazards of that work area and those health effects that would not be detected reasonably until the future because of the latent period for the medical hazard.

Evaluation

It is recommended that an independent evaluation of the effectiveness of the employee educational program be carried out on a periodic basis, but not less frequently than every three years. This evaluation should include a review of the documentation of the education efforts undertaken and participation rates for employees, in carrying out the objectives of informed consent of persons assigned to conduct the educational program.

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