A PROSPECTIVE MEDICAL SURVEILLANCE PROGRAM FOR THE DETECTION AND PREVENTION OF INDUSTRIALLY RELATED CANCER*

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I. INTRODUCTION

The extent of occupational disease in the United States is unknown; one of the reasons for this is that we have not, as yet, developed the routine mechanisms for the collection, storage and analysis of the required data. Rose et al. (1), recently identified three major elements that must be developed to study the national occupational health: 1) uniform methods for maintaining medical surveillance of the incidence and prevalence of occupational disease; 2) a system for monitoring all aspects of the work environment that may contribute to occupational disease; and, 3) better application of existing methods and the development of better methods to establish scientifically the relationships between occupational disease and the work environment.

We would like to discuss the elements of a system of medical surveillance now being developed for a cohort of industrial workers known to have been exposed, in varying degrees, to a known carcinogen, vinyl chloride. Perhaps a brief history is in order. Since 1974, seven cases of angiosarcoma of the liver have been discovered at the B.F. Goodrich Chemical plant among workers exposed to vinyl chloride. The company has been

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in operation in Louisville since 1941. Plant personnel represent a cross section of the working population with jobs ranging from manual labor to highly skilled technical and professional positions. The average employee has approximately thirteen years service. There are currently about 1,200 employees. Although the number has changed continuously due to technology and economic conditions, the rate of change has been relatively low.

In response to the discovery of angiosarcoma in 1974, a screening program was initiated as a joint effort of the B.F. Goodrich Company and the University of Louisville. This effort has since been expanded by a direct grant to the University of Louisville Cancer Center by a contract from the National Cancer Institute, Division of Cancer Control and Rehabilitation. In addition to medical surveillance, the program includes education and psychosocial rehabilitation.

II. MEDICAL SURVEILLANCE SYSTEMS

The medical surveillance system is composed of four ordered levels of screening. Each increased level tends to improve the total precision but at an ever increasing cost and complexity. The ideal for these programs is to obtain a maximum capability of discovering potential occupationally-induced cancer (sensitivity) at an economic and social cost acceptable to management, labor, federal regulatory agencies and the individual employee. The program should also be readily transferable to other industries.

Level I is the minimum needed for an effective surveillance system in an industrial environment; it is applicable in industries of limited economic capability and/or a low expected rate of industrial illness of cancer. It serves as the foundation for all additional levels of screening and surveillance. This level contains three major components: 1) the employees' work history. This should include a chronological summary of each job an employee has held within the industrial complex. 2) An exposure history for each job. This would be a subjective determination of which agents or chemicals are or have been associated with each particular job. This estimate is based upon all available data and should be as quantitative as knowledge of the operation will permit, i.e., it would usually be a binary or rank order statistic. 3) The medical history. The medical history of each employee should be determined upon initial employment and should include previous hospitalizations and illness. Subsequent

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absences due to illness should be recorded and should include the cause of illness. Final diagnosis for hospitalization should be obtained as part of the medical history. This would constitute the morbidity data. In addition, when possible, the death certificates for current or former employees should be obtained as part of the final medical history. This would constitute the basis for the mortality data.

Level II would add to the detailed medical history and would include a physical examination. Specific information and physical determinations related to the suspected industrial problem would be obtained. The exposure data would be extended to include area monitoring for suspected industrial toxins or carcinogens. The medical screening program would be instituted and would include simple laboratory screening, such as blood and urine determinations; biochemical studies, utilizing the simplest available methods of detecting specific system disorders; radiological studies, consisting of common procedures such as x-rays of the chest and limbs; and finally, specific functional studies, designed to screen those selected body systems most likely to be involved as a result of exposure to the industrial environment.

At Level III, the exposure data would be expanded to include individual monitoring in addition to area monitoring and subjective job evaluation. The medical screening system would utilize studies designed for more specific purposes aimed at a target system organ. For example, in the case of the hepatobiliary system, specific enzymes (serum glutamic oxaloacetic transaminase, serum glutamic pyruvic transaminase); substance clearances (indocyanine green, bile acids); and protein determinations (albumin, globulin, etc) would be utilized. In addition, radiological studies would now include more sophisticated techniques such as liver, spleen and lung scans. Finally, functional studies such as pulmonary ventilation, cardiac monitoring, and muscle exercise testing, would be initiated.

The fourth level of medical surveillance requires the addition of two more major elements: 1) an educational program designed to inform, educate and encourage participation of the employees in the screening procedures on a continuing and systematic basis. 2) A counseling and follow-up program for psychosocial rehabilitation to assist asymptomatic individuals, identified as being at high risk of industrial disease, and individuals incidentally discovered to have early industrial or non-industrial related illness. Furthermore, counseling and assistance will be needed

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for the symptomatic employee who will require occupational rehabilitation to new or modified forms of employment. This latter component of the medical surveillance system will allow the proper orientation and individual adaptation to the medical screening procedures, both for employees and management. Due to the great complexity of the medical surveillance system, it is highly improbable that a Level III system can be carried out without a Level IV system.

III. RESULTS

The following are brief descriptions of our progress and current thinking as regards several of the important but non-medical aspects of our medical surveillance system.

A. Exposure

Dr. A.M. Fairlie, J.R. Kute, J.C. Schaap, R.L. Rowles and W.J. Wilcox of the B.F. Goodrich Company initiated the development of the following system for obtaining chemical exposures and employee work histories and for combining them according to job classification into various indices of length and severity of exposure:

1. JOB CLASSIFICATION CODE

Each job classification in each building is given a separate job classification code. Codes also identify jobs outside the local plant, layoffs, termination and retirement.

2. EMPLOYEE WORK HISTORY

The work history for each employee consists of the date he was assigned to each job, the job classification code for the new job and the job classification code for his last job. It includes, in chronological order, the employee's complete work history.

3. CHEMICAL EXPOSURE

A six-point rank order scale of exposure is subjectively obtained once each year for each of the nineteen chemicals by each job classification code.

4. EXPOSURE INDICES

The employee work histories and the associated chemical exposures are combined by job code to produce the fourteen indices of exposure per chemical. Thus far, our interest has concentrated on two of these indices:

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a. The Average Exposure Index

$$\text{Average Exposure} = \frac{\Sigma_i n_i E_i}{\Sigma_i n_i}$$

Where n_i = number of months at exposure level E_i, and

b. The Total Exposure Index

$$\text{Total Exposure} = \Sigma_i n_i E_i = \Sigma_i n_i \left[\text{average exposure}\right]$$

We are also interested in the interaction term defined by the product of these exposure indices:

$$\text{Interaction Exposure} = \frac{\Sigma_i (n_i E_i)^2}{\Sigma_i n_i}$$

These two indices will be tabulated on a calendar year basis and for selected linear combinations of calendar years.

B. The Evaluation of Screening

The screening tests will be evaluated in terms of their usefulness in detecting overt disease and in terms of their ability to detect early abnormalities that may be indicative of future overt disease. To evaluate the ability of a screening test to detect disease, we must be able to cross-classify employees according to whether the test indicates the presence or absence of disease and according to whether the disease is actually present. Given this information, we evaluate the test by estimating its sensitivity and specificity. This can be done even in the presence of errors in the so-called true classification. As is well-known, in a population in which the prevalence of disease is low, we will obtain imprecise estimates of sensitivity but precise estimates of specificity. Laboratory experiments with rats will parallel our surveillance program. The rats will be subject of identical screening procedures and then sacrificed and autopsied. Estimates of sensitivity and specificity will also be obtained for this population of rats.

To study the ability of the screening tests to predict future disease, we will record current results and trends and compare them with the presence or absence of disease at some time in the future, say at yearly intervals.

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A second use of the screening tests will be to relate them to past exposure. If abnormal screening tests are related to previous exposure, they may also be related to future disease. Such findings could be considered an early warning; they will also help form the basis for epidemiological studies and animal experiments.

C. Early Warning

Mortality and morbidity rates will be monitored and compared with our best estimates of expected rates. Excess rates with $\alpha = 25\%$ will warn us of a possible risk factor, and appropriate action will be taken. For example, surveillance of 1,200 employees for three years would provide approximately a three-in-ten chance of detecting a four-fold increase in lung cancer in a subset of 250 employees.

IV. DISCUSSION

The major facets of any surveillance system capable of detecting early occupational disease must include each of the following:

1. Accurate records must be maintained on the work histories of all employees.
2. Information must be carefully ascertained and recorded concerning exposure to various agents for each area and job classification.
3. The health status of the employees must be continuously monitored and compared to that expected in a similar non-exposed population. This should include both morbidity and mortality.
4. Screening tests capable of detecting early abnormalities must be given periodically, the results carefully maintained and compared with previous exposures and later with future health.

A Level I surveillance system is the foundation for an expanded system and by itself provides sufficient data to alert management and labor to the necessity of moving to a higher level.

We are actively establishing a Level IV system. Work histories and job exposures are routinely being collected on all employees since

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January 1, 1974. They will be updated quarterly. The first round of physical examinations and screening tests carried out under our supervision should be completed this coming summer. The data being collected are being coded and stored on magnetic discs. Computer programs for the rapid access and analysis of the data are being written. Some preliminary analysis and evaluation will be begun this summer.

V. SUMMARY

A surveillance system designed to detect early occupational disease is being established for the B.F. Goodrich Chemical Company's Louisville plant. The system will routinely collect and maintain records of work histories and job exposures. It will monitor the health of employees through annual and semi-annual physical examinations and through semi-annual and quarterly screening tests. The data are stored in computer-accessible form, and methods for the early warning of both overt and potential disease are being developed.

REFERENCE

1. Rose, V.E., Lee, J.S., and Kusnetz, H.L. National Surveillance Network for Occupational Health. J. Occup. Med., 12:193-197, 1970.

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