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RESEARCH REPORT

**A Conceptual Framework for  
Occupational Health  
Surveillance**

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A CONCEPTUAL FRAMEWORK FOR OCCUPATIONAL HEALTH SURVEILLANCE

Robert Spirtas, Dr. P.H.\*  
David S. Sundin, M.B.A.\*  
John P. Sestito, M.S.\*  
Virginia J. Behrens, M.S.\*  
Jean French, Dr. P.H.\*\*

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE  
Public Health Service  
Center for Disease Control  
National Institute for Occupational Safety and Health  
Division of Surveillance, Hazard Evaluations, and Field Studies\*  
Office of Extramural Coordination and Special Projects\*\*  
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## ABSTRACT

This paper explores the current state of the art in occupational health surveillance. A flow diagram is presented which shows how various sources of data can be combined to facilitate the flow of information necessary for a better understanding of occupational health hazards. Information derived from such a program will permit the systematic identification of high-risk occupational groups, relate exposures to specific health outcomes, and provide data which are prerequisite for the prioritization of needs in research, evaluation, and control. A comparison is made with surveillance systems in other countries.



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## DEFINITIONS AND GOALS

The area of occupational health surveillance requires the integration of elements of illness or disease surveillance with elements of hazard or environmental surveillance. The following definitions of disease surveillance are borrowed from the field of infectious disease surveillance. The World Health Organization defined disease surveillance as "a concerted attempt to keep under continuous observation all the factors that contribute significantly to the occurrence of disease in human populations" (1). This definition tells how to do surveillance. During the deliberations of the NIOSH Surveillance Task Force, Dr. Alex D. Langmuir stated that "any surveillance program must include the capability to collect, analyze, and disseminate information" (2). The second definition tells what needs to be done by a surveillance program. In addition, it implies the necessity for a coordinated systematic approach, rather than trying to patch together fragmented pieces of programs with differing goals. The National Air Surveillance Network program, which was run by a predecessor to the Environmental Protection Agency, defined its objectives to include the "determination of the nature and extent of air pollution and the study of trends in the levels of various atmospheric contaminants" (3). This example of environmental surveillance emphasized the repeated measurement, over time, of a representative sample of the nation's ambient atmosphere. Throughout this paper the two concepts of continuous monitoring and systematic approach will be stressed.

## SCALE OF OPERATIONS

In order to help conceptualize the appropriate levels of activity for the evolving surveillance program, it is necessary to discuss three levels of surveillance: macro, meso, and micro. The macro level includes studies of the entire workforce or a sample therefrom. At this level of operation it should be conceptually possible to make estimates of the nationwide levels and trends in occupational hazards and health effects.

The National Occupational Hazard Survey (NOHS), conducted by the National Institute for Occupational Safety and Health, is an example of hazard surveillance at the macro level. In this study, a representative sample of approximately 5000 facilities was selected for workplace environmental evaluation according to a specified protocol (4). The consequent walk-through surveys, conducted during the period 1972-1974, resulted in a data base of over five million records. The main weakness of the NOHS is that it represents, essentially, a sample taken at one point in time, which becomes less valid as new substances are introduced into the workplace over time. In addition, the lack of concomitant data on health effects limits the utility of the data.

Unfortunately, the efforts to date in the macro health surveillance area have been largely restricted to mortality studies. The work of Guralnick, utilizing death certificates from the 1950 period, remains as the most comprehensive study relating occupation and industry to mortality in this country (5,6). A more complete discussion of current sources of data can be found in the previously cited NIOSH Task Force Report (2).

Surveillance at the meso level would tend to involve studies of entire industries, trade associations, and unions. Alternately, such a study might be defined by data from a state or other geopolitical unit. An example of this level of study is Milham's Analysis of Occupational Mortality in Washington State (7). Data obtained at the micro level would probably not support the development of large-scale data bases capable of statistical inferences. The utility of such data would include identifying casehistories of occupational disease and disseminating this information to appropriate groups. For example, micro surveillance would include evaluation of medical and environmental data on workers examined as part of a NIOSH Health Hazard Evaluation Survey. Such information might be useful as an early warning signal.

Figure 1 depicts a range of possible occupational health surveillance data collection activities.

The range of disciplines presented in Figure 1 is not meant to be exhaustive. Indeed, it will be necessary to utilize the skills of biostatistics, systems analysis, ergonomics, physiology and psychology, as well as other disciplines. In addition, the categories presented are arbitrary and do not cover all situations. Thus, it would be possible to do toxicologic research utilizing samples of a workplace environment. Sometimes it is necessary to use indices when precise data is not available. Thus, work history information is often used to assess exposures when analytical monitoring results are not available. The main point is that a systematic approach to occupational health surveillance must, by the nature of the expertise required, be a team effort. In order to effectively carry out a systematic program of hazard and illness surveillance it is imperative to integrate the full gamut of available, as well as derived, information.

FIGURE 1  
 SPECTRUM FOR OCCUPATIONAL HEALTH SURVEILLANCE DATA

Area of Specialty/Scientific Discipline

Variable Monitored	Toxicology	Industrial Hygiene	Industrial Medicine	Epidemiology
Pure Chemical & Physical Agents	H,E			
Industrial Grade Materials	H,E	H		
Workplace Environment		H	E	
Workers		H	E	H,E
Sick People			E	E
Deaths				E

H denotes monitoring of the hazard or causal agent.  
 E denotes monitoring of the health outcome or effect.

## COMPARISON OF SURVEILLANCE EFFORTS IN OTHER COUNTRIES

In his dissertation, Rose discusses specific governmental programs in Canada, Great Britain, Czechoslovakia, West Germany, France, Australia, and Japan (8). His study can be interpreted as showing that an industrialized country's ability to do occupational health surveillance is related to the degree that statistical activities are centralized in the given country. He discusses the use of schedules (lists of reportable occupational diseases) as opposed to "general coverage." The former approach is considered to offer more protection for the worker for conditions specifically enumerated, while the latter is held to be more flexible. Some countries use a combination of the two approaches. In addition, researchers in Europe (9,10) and Canada (11) are beginning to utilize cancer registries as a means of occupational health surveillance. Efforts at medical surveillance of groups at high risk from a known exposure date back at least 20 years; i.e. the bladder cancer screening program for  $\beta$ -naphthylamine-exposed workers conducted by the British Rubber Manufacturers Association (2).

By comparison, the present reporting systems in the U.S. are inadequate for occupational health surveillance. For workman's compensation, each state determines (on a case by case basis) whether a given condition is compensable. To be compensable a case must be shown to be occupationally related and to have resulted in lost time from the job. Only claims actually paid are reported. Usually the reporting scheme concentrates on financial matters, thus ignoring the breakdown by cause or condition which would be necessary to be useable in a surveillance system. The annual Bureau of Labor Statistics survey utilizing data collected for the Occupational Safety and Health Administration has concentrated on occupational injuries, and is felt to under report occupationally induced illnesses (13,14). Current efforts are under way to upgrade existing data collection schemes. In addition, it is possible to merge efforts of governmental data collection agencies in the U.S. to produce a greatly improved surveillance system.

## PROPOSED SURVEILLANCE MODEL

Figure 2 depicts the flow of information within the proposed surveillance system. New information is continuously entered into the system; recommendations for standards and controls, as well as direct communications with unions, employers, and workers emanate from the system.

Although somewhat oversimplified, we will define health effects data to include results from epidemiological and clinical data on humans, as well as data from animal testing and microbial systems. Sources of such data include epidemiological studies of occupational cohorts, toxicologic studies, and clinical case histories, as well as administrative data sources such as workmen's compensation files.

From the derived data it will be possible to identify high risk groups. A great deal of judgement would be required at this stage by people who can interpret both toxicologic and epidemiologic studies. By querying the NOHS, it should be feasible to estimate the number of workers exposed to a given, high risk agent or industry/occupational category, along with some information on the degree of control for the given hazard. Then it should be possible to develop an algorithm which would rank order various categories of risk given varying input parameters.

The input to the ranking would be related to the risk, R, where

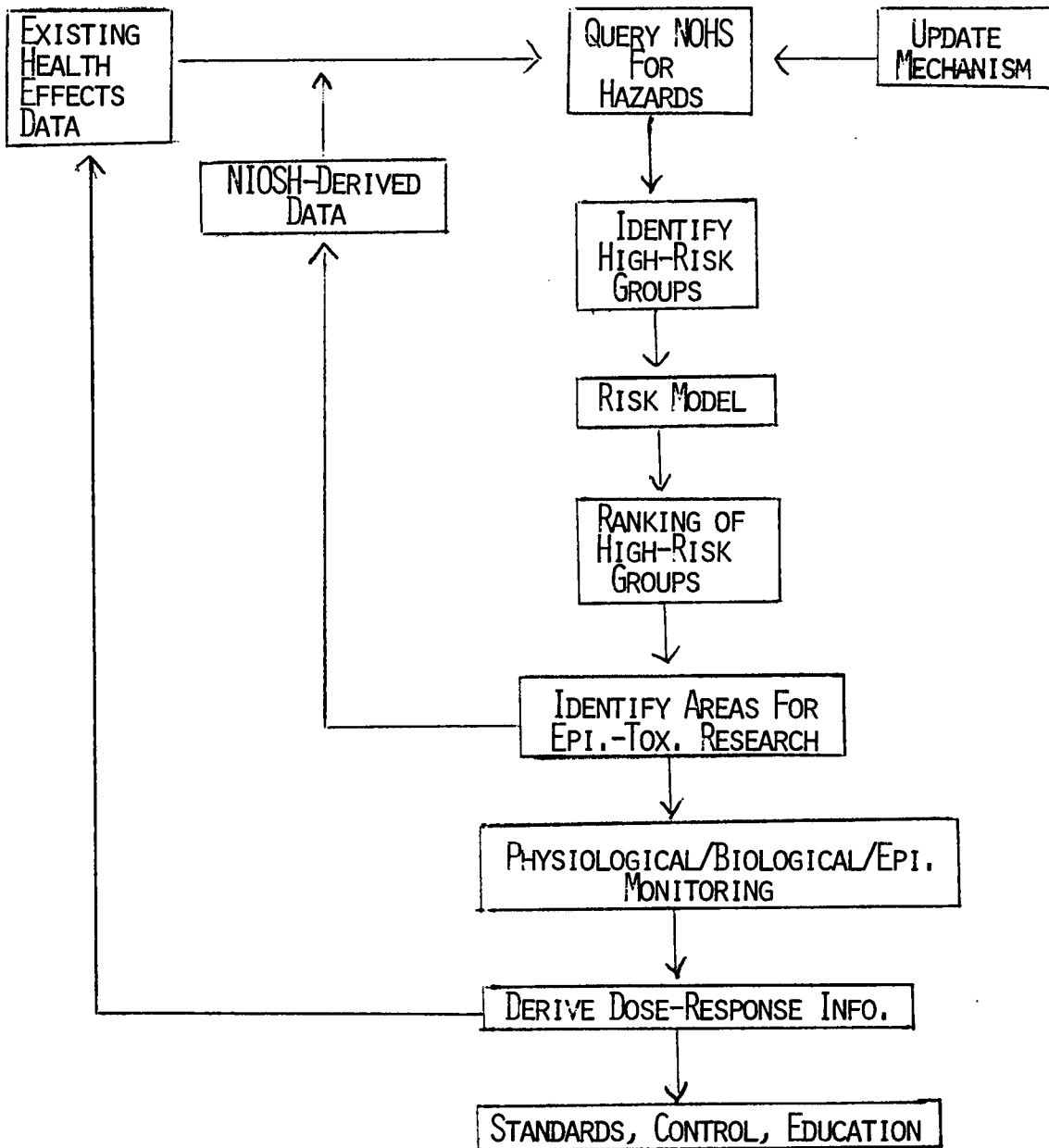
$$R = F (\text{toxic level, level of exposure, population exposed, control technology, analytical monitoring capability for biological and chemical samples}).$$

The associated output filtered through a process of expert evaluation and interpretation could assist in developing priorities for toxicologic and/or epidemiologic research.

The output of this research could be used to upgrade information on high risk groups, as well as to better define appropriate groups for continuous monitoring, possibly along the lines of the NIOSH program for medical surveillance of coal workers (5). In turn the results of medical surveillance could be expected to yield better dose-response information. Obviously, surveillance for acute effects will require different procedures than surveillance for chronic effects. Thus, for example, the use of questionnaires in working populations may be appropriate in screening for dermatitis, while cancer surveillance may require cytologic screening of non-working groups. One output of the system should be information which is suitable

for various uses, including standards setting, priorities for control and education of labor and management. The dissemination of this information would be a function requiring sensitivity, as well as scientific objectivity. To many people in the general public the dissemination function is their only contact with NIOSH, so it is imperative that any information requested be generated quickly, efficiently, and with some attention to meeting the needs of the requestor.

FIGURE 2  
SURVEILLANCE MODEL



## PROGRAM ELEMENTS

The necessary elements of a program to acquire the surveillance information necessary to characterize the nationwide scope of the occupational health hazard problem and the resulting illness effects follow:

### A. INITIATIVES FOR HAZARD SURVEILLANCE

The program which is proposed for current and continuing surveillance of occupational health hazards consists of four initiative areas:

#### 1. Development of Existing Data Bases

The National Occupational Hazard Survey (NOHS) has evolved as a data base with potent capabilities. This data base will be interfaced with the Registry of Toxic Effects of Chemical Substances (RTECS) in an attempt to add health effects information to the potential exposure information contained in NOHS. Additionally, the Trade Name Ingredient data base will be further developed to provide information on chemical compositions of a wide spectrum of industrial products. Effort will be directed toward making these bases efficiently accessible to a wide range of users.

#### 2. Identification of High Risk Occupational/Industrial Groups

This effort will focus on integrating data from a variety of sources with the overall goal of prioritizing occupational groups or industry types with a high potential exposure to health hazards. A key project will involve assigning severity indices to the list of 7,000+ hazards identified during NOHS, and the development of a risk modeling algorithm.

#### 3. Development of Mechanisms to Collect Employer and Employee-Derived Exposure Information

Mechanisms will be designed and tested which will permit national surveys of industrial facilities through cooperative interaction with employers and employees. The Standards Completion Program has produced recommended standards requiring employers to monitor environmental levels of certain agents, as well as collecting medical information on exposed employees. The proposed regulations are, however, largely silent on the form in which the data is to be collected. Attention should be directed towards simplifying the data collection process and developing guidelines and forms for use by employers.

#### 4. Development of Early-Warning Systems for Hazardous Agents

The necessity to acquire early information on the agents' potential for deleterious health effects in the industrial environment is obvious. Hazard surveillance efforts in this regard should concentrate on close liaison with the Office of Toxic Substances - EPA during the early stages of implementing the Toxic Substances Control Act to insure that data which is collected is in a format useful to NIOSH. Additionally, the potential for utilizing structure-activity models in a predictive toxicology system could be explored. Further, the feasibility of screening of metabolites for mutagenic activity among groups potentially exposed to agents of interest might be investigated.

#### B. INITIATIVES FOR ILLNESS EFFECTS SURVEILLANCE

The program proposed for surveillance of illness effects is composed of four initiatives:

##### 1. Surveillance of High Risk Occupational/Industrial Groups

Following the approach used in the NIOSH Registry of Kepone/Mirex workers, NIOSH anticipates placing three more groups under surveillance in FY'78. The purposes of the approach include:

- a. Generation of list of names and addresses for baseline data.
- b. Creation of cohort for prospective morbidity and mortality studies.
- c. Creation of file for dissemination of information and/or intervention - screening studies.

##### 2. Utilization of Existing Data as Collected by Federal, State, and Local Agencies as well as Private Sector.

Included in this category are data from the Third National Cancer Survey, HIS tapes from NCHS and SSA data on disability retirees. Analysis of these data files is expected to proceed in collaboration with other investigators.

3. Interagency Coordination with Core (Bureau of the Census, Bureau of Labor Statistics), Functional (National Center for Health Statistics, Bureau of Mines, Environmental Protection Agency), and Multipurpose (Data) Collection Agencies.

Here is envisioned the development of interagency programs to take advantage of the data collection and processing capabilities of other federal agencies. This includes continued involvement in the Fetal Mortality Study (NCHS), collaboration with BLS-OSHA on a health questionnaire as well as a registry of chemical poisonings, interactions with cancer registries (NCI), further collaboration with SSA, and development of contacts with the Bureau of the Census.

4. Development of Mechanisms and Sources for Data Collection, Analysis, and Dissemination.

Included here are ways to utilize the following data sources:

- a. SSA work history data
- b. Hospital acquired data (including comprehensive cancer centers)
- c. Health maintenance organization files
- d. NIOSH Health Hazard Evaluation Data

## CONCLUSION

A recognized gap exists in the development of a comprehensive surveillance effort. The present system relies too heavily on the in vivo experiment with dangerously toxic chemicals which is being carried out day-by-day in workplaces throughout the country. The surveillance of hazards and diseases cannot realistically proceed in isolation from each other. The successful characterization of the hazards associated with different industries or occupations, in conjunction with toxicological/medical information relating to the hazards, can suggest industries or occupational groups appropriate for epidemiologic surveillance. Conversely, unusual health patterns in certain industries or occupations elucidated by surveillance of health effects will be more fully explained by surveillance of the potentially causative agents. A few disease entities are sufficiently cause-specific to diminish the need for hazard surveillance, e.g. angiosarcoma induced by vinyl chloride, thorostrast, or arsenic. Some agents are sufficiently effect-specific to make the task of illness surveillance relatively straightforward, e.g.  $\beta$ -naphthylamine induced bladder cancer. There is, however, a vast middle ground where exposures are complex, and symptoms diverse, that lends itself to resolution only through the combined efforts of cause and effect surveillance. Of particular importance is the need to carefully analyze and disseminate data generated by any surveillance system.

The conceptual model discussed in this paper would alter and, in some cases, increase the data collection activities in the occupational health community. Some of these ideas are controversial, especially the proposal for increased medical surveillance of workers (6). However, without a major change in the way data on occupational hazards and health effects is collected, it will remain an impossible task to do an adequate job of occupational health surveillance. In addition, it is of particular importance to carefully analyze data collected by any surveillance system. And finally, the dissemination of results will require a great deal of judgement, as well as objectivity.

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