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Surveillance in Occupational Health and Safety

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SURVEILLANCE IN OCCUPATIONAL HEALTH AND SAFETY

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SURVEILLANCE IN OCCUPATIONAL SAFETY AND HEALTH
Edward L. Baker, MD, *Editor*

Compiled by the
National Institute for Occupational Safety and Health
Centers for Disease Control

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ILLUSTRATIONS

ACKNOWLEDGMENTS

This publication is the result of the efforts and talents of many people.

Experts in many different disciplines have graciously given of their valuable time, offering advice and criticism throughout the development of this monograph. Gratitude is extended to all, and it is hoped that the result approaches their expectations. It is a pleasure to recognize and acknowledge their continued support and guidance in our surveillance efforts.

As is stated in the Introduction, this monograph could not have been completed without the extraordinary contributions of the Surveillance Evaluation Group. Their names and affiliations are listed immediately following the Introduction.

Sincere thanks are also extended to the many staff members of the National Institute for Occupational Safety and Health who contributed to this project. Special thanks are extended to Mrs. Betty Dryden and Miss Yvette Redding for coordinating meetings; to Miss Redding, Mrs. Barbara Greene and Miss Bethany Boynton for retyping almost all the text and for additional preparations of the manuscript; to Mrs. Jeanne Bucsela for her stylistic editing; and to Dr. Richard Ehrenberg, Mr. Todd Frazier and Dr. David Wegman for their contributions as Associate Editors throughout the preparation of this monograph. As Assistant Editor, Ms. Linda Webb performed the essential tasks of organizing the entire project and working with authors to submit and revise their manuscripts in a timely fashion.

Particular gratitude is extended to Mrs. Mary Ann Fenley for technical editing and for her exceptional talents in drawing this monograph together with clarity, uniformity and continuity.

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PREFACE

When I first served as Acting Director of the National Institute for Occupational Safety and Health (NIOSH) for six months in 1978, I became aware of the activities in the Surveillance Task Force chaired by Dr. Alexander Langmuir. This task force had been created in 1976 by Dr. Jack Finklea to address the problems of establishing a viable surveillance program for NIOSH. Several years later, Dr. Langmuir told me that the surveillance of occupational health was the most complex surveillance problem he had ever faced.

After I became Director of NIOSH in 1981, the full impact of his statement became apparent to me. The several reasons for this complexity stem from the three main activities that define surveillance. First is the collection of relevant data. In the surveillance of occupational health, the relevant data include both information about the *hazards* found in the workplace and data needed to describe work-related *injuries and disease*. Second, analysis of the data provides opportunities—and complexities—for linking hazards to injury and disease parameters. Finally, these analytic results must be disseminated in ways that will initiate a chain of events to accomplish our ultimate goal, the prevention of work-related injury and disease.

The papers in this monograph indicate the significant progress we have made in developing surveillance systems for occupational health and safety. NIOSH has made two national surveys of workplace hazards. As the task force chaired by Dr. Langmuir recommended, existing data systems for natality, mortality, and morbidity have been adapted for use in occupational safety and hazard surveillance. Associations have been made between workplace hazards and disease using linkages found in the Job Exposure Matrix. Collaboration developed through the funding of cooperative agreements between NIOSH and the states has established channels for the effective dissemination of information. At the present stage of developing a surveillance system, it is necessary to strengthen our ties with private medical practitioners, and this is the aim of the Sentinel Event Notification System for Occupational Risks (SENSOR).

Although I am proud of these accomplishments, I am also aware of the need to evaluate our progress by viewing our programs somewhat critically. The collection of papers in this monograph describes the current status of surveillance for occupational health and safety. I hope it will stimulate members of the public health community to share with us their reactions to our efforts.

J. Donald Millar, MD
Assistant Surgeon General
Director, NIOSH

EXECUTIVE SUMMARY

At times, the act of setting collected ideas and plans in print helps to advance the course of thought and action. This monograph provides a summary of current efforts in the emerging field of surveillance for occupational safety and health. It explores the strengths and weaknesses of these efforts, and outlines and projects future directions to advance the field. We hope it will stimulate the reader to consider the complexities of occupational health surveillance and that it will provide guidance for surveillance programs throughout the United States and abroad.

Since its creation in 1970, the National Institute for Occupational Safety and Health (NIOSH) has designed and carried out surveillance projects to address specific occupational health problems. These activities have often used existing data sources or, when necessary, have collected data directly for this purpose. Although each project was reviewed individually before its execution, no comprehensive evaluation of the entire NIOSH surveillance effort had ever been performed. In 1986, NIOSH initiated a project to evaluate its surveillance efforts. Many of the papers in this monograph were begun as part of this evaluation, and other relevant surveillance issues, particularly the surveillance performed by state health departments, were also slated for inclusion.

Since the early 1980s, NIOSH has encouraged and supported state health departments to build a capacity for surveillance of occupational illness and injury. Over a five-year period, the earliest such effort—Surveillance Cooperative Agreements between NIOSH and States (SCANS)—substantially improved the level of state capabilities for using existing records (e.g., birth and death certificates) in surveillance. Two subsequent cooperative ventures have further expanded the surveillance capacity of state health departments. These activities include a set of 9 projects initiated in 1983 and, more recently, a group of 10 projects, the Sentinel Event Notification System for Occupational Risks (SENSOR), in 1987. As the scope of surveillance activities has expanded, NIOSH has provided guidance to states. This monograph represents a continuation of that effort and includes articles on current types of surveillance activities and future directions.

The monograph addresses not only state health departments but also the growing number of health care providers (individuals as well as institutions) involved in the surveillance of occupational health. As the roles of these providers have expanded markedly, their needs have increased proportionately. For example, to give meaning to the now-dormant state regulations requiring providers to report occupational illnesses and injuries to state health departments, providers must know what to report and have a simple decision logic to apply in individual cases. These issues are treated here directly. Furthermore, the monograph offers guidance to help providers standardize the individual, periodic health examinations they perform routinely as a part of overall surveillance programs.

We view this monograph as providing the base for a dynamic system that will be updated and expanded over time. For example, as epidemiologic case definitions for selected occupational disorders are developed and reviewed, they will be published in the *Morbidity and Mortality Weekly Report* of the Centers for Disease Control. A complete questionnaire for occupational health surveys will be published in the near future and will include pertinent instructions for interviewers.

We invite comments from readers of this monograph and we look forward to working with many individuals and groups throughout the United States to build a comprehensive national system for the surveillance of occupational illness and injury in this country.

This monograph represents an 18-month collaboration between NIOSH researchers and occupational health experts from various state health departments and academic institutions in the United States and abroad. The persons who served as authors of individual manuscripts and as reviewers of other papers are listed below as well as with the specific articles to which they contributed. Most participants met together in Atlanta twice during this process and communicated with each other regularly throughout. This monograph could never have been written without the extraordinary contributions of this outstanding group.

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ACRONYMS USED IN THE MONOGRAPH

ACGIH	American Conference of Governmental Industrial Hygienists
ANPR	Advanced Notice of Proposed Rulemaking
ANSI	American National Standards Institute
AOEC	Association of Occupational and Environmental Clinics
ATS	American Thoracic Society
BLS	Bureau of Labor Statistics
CDC	Centers for Disease Control
CES	Cooperative Exposure Survey
CSTE	Council of State and Territorial Epidemiologists
CTS	Carpal Tunnel Syndrome
DHHS	Department of Health and Human Services
DOT	Dictionary of Occupational Titles
DSR	Division of Safety Research
EPA	Environmental Protection Agency
FACE	Fatal Accident Circumstances and Epidemiology
HHE	Health Hazard Evaluation
HMO	Health Maintenance Organization
I&O	Industry and Occupational
ICD	International Classification of Diseases
IMIS	Integrated Management Information System
IOM	Industry-Occupational Matrix
JEM	Job Exposure Matrix
MOR	Mortality Odds Ratio
MSHA	Mine Safety and Health Administration
NAS	National Academy of Sciences
NCHS	National Center for Health Statistics
NCI	National Cancer Institute
NEISS	National Electronic Injury Surveillance System
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NIOSH	National Institute for Occupational Safety and Health
NMIHS	National Maternal and Infant Health Survey
NNS	National Natality Survey
NOES	National Occupational Exposure Survey
NOHS	National Occupational Hazard Survey
NOHSM	National Occupational Health Survey of Mining
NSN	National Surveillance Network
NTOF	National Traumatic Occupational Fatalities
OES	Occupational Employment Statistics
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PHS	Public Health Service
PMR	Proportionate Mortality Ratios
PTS	Predictive Toxicology System
RTECS	Registry of Toxic Effects of Chemical Substances
SCANS	Surveillance Cooperative Agreements Between NIOSH and States
SDS	Supplementary Data System
SENSOR	Sentinel Event Notification System for Occupational Risks
SHE(O)	Sentinel Health Events (Occupational)
SIC	Standard Industrial Classification
TLV	Threshold Limit Value
WHO	World Health Organization
WIR	Work Injury Reports

I. Surveillance in Occupational Illness and Injury: Concepts and Content

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The Nature and Purpose of Surveillance Programs in Occupational Health

Epidemiologic surveillance is the ongoing and systematic collection, analysis, and interpretation of data related to health. This information is used to plan, implement, and evaluate public health interventions.[1] Occupational surveillance programs identify instances of illness, injury, or excessive exposure and monitor trends in their occurrences across different industry types, over time, and between geographic areas.[2]

Case identification may benefit not only the affected individual but also his or her co-workers. For example, identifying a case of lead poisoning should not only remove the worker from exposure, but also should lead to screening of co-workers to identify and manage other cases. Thus, the case represents an Occupational Sentinel Health Event.[3] If case identification is followed by a worksite evaluation, exposure hazards can be controlled. Although the term "case" is typically used to designate an instance of a disease in a person, the individual occurrence of an acute occupational injury, excessive absorption of a toxic substance, or excessive personal exposure are all events that have been placed under surveillance. Identification of such "cases" can result in significant benefits to the individual.

Trend monitoring is essential in evaluating the overall effectiveness of worksite control programs. Increased rates of injury, illness, or exposure identify targets for enhanced worksite intervention. In targeting intervention programs, surveillance directs "the most important ethical decision in public health": the appropriate allocation of resources.[4]

In public health, the term "surveillance" has a broader meaning than is indicated by its usage to describe certain occupational health programs. In occupational health, the term "screening" should be used to describe programs that include a medical history, physical examination, and laboratory tests to detect a specific disease process at an early, potentially reversible stage.[5,6] As discussed in this article, medical screening is one type of surveillance activity. Under Occupational Safety and Health Administration (OSHA) standards, a primary purpose of medical surveillance is to detect affected individuals through screening.[7] Surveillance includes a wider range of activities than is required for most OSHA standards.[8]

Health Surveillance

Data Sources

A variety of data sources have been used to monitor trends of occupational illness and injury. These include: employer reports, death certificates, birth certificates, Workers' Compensation records, clinical laboratory data, medical examiner reports, hospital discharge records, and national health surveys. Typically these databases were developed for purposes other than surveillance and have important limitations.[2] Some hold promise for monitoring selected conditions in individual states (e.g., blood lead test results collected by state laboratories). Others hold promise for more intensive surveillance efforts (e.g., the National Health Interview Survey).

Case Identification

Two types of programs exist that identify cases of occupational illness or injury. Screening programs and health-care-provider reporting programs are designed to identify individuals so that action can be taken. Screening programs are often mandated by OSHA standards covering exposure to specific workplace hazards (e.g., lead and cotton dust). Under such standards, employees are required to perform screening to identify individuals with evidence of excessive absorption of a toxic agent or organ system dysfunction and remove them from exposure to the offending agent. Although such programs are in wide use, standardized screening techniques are available for only a very limited number of applications.

Most states have regulations that require reporting of occupational disease to an agency of state government.[9] However, most programs are not effective due to strong disincentives for physicians and others to report occupational diseases.[2,9] Follow-up of cases that are reported to state government is infrequent. Finally, absence of clear case

NOTE: Author affiliations and addresses are listed on p. 7.

definitions for occupational disorders has created ambiguity in reporting criteria and nonuniformity of reports.

Trend Monitoring

Employer Reporting—The Annual Survey of the Bureau of Labor Statistics

The largest national program to monitor trends in the occurrence of occupational disease and injury is the Annual Survey of the Bureau of Labor Statistics (BLS). This survey utilizes employer reports to estimate annual rates of occupational disease and injury for the United States. These estimates are used regularly to characterize the effectiveness of control programs, particularly those of OSHA.

The BLS Annual Survey has been criticized for underestimating the true burden of occupational illness and injury.[10] Such underestimation may result in distortion of information needed for control program evaluation and in inadequate support for such programs. As a result of these concerns, BLS is currently restructuring the Annual Survey and other BLS surveillance programs. Despite the limitations of the Annual Survey, much useful data are available, particularly for acute traumatic injuries.

Surveillance Based on Death Certificates

As discussed elsewhere in this monograph (see chapter IX), death certificates provide a uniform database for monitoring trends in the occurrence of selected occupational disorders. The utility of this approach is limited by the quality of the occupational history as recorded on death certificates. Furthermore, mortality records, by definition, do not detect nonfatal conditions. Finally, most fatal conditions that are caused by work can also be caused by other factors.

Despite these limitations, death certificates can be very useful in surveillance. One of the best demonstrations of such usefulness is the NIOSH National Traumatic Occupational Fatality (NTOF) Database. Using certificates from all 50 states and the District of Columbia, this database currently provides a comprehensive estimate of US fatality rates due to occupational factors. (See chapter VIII in this monograph.)

Exposure Surveillance

Measurement of airborne contaminant concentrations in the workplace has been used for many years to evaluate the efficacy of engineering controls for limiting exposure to toxic substances. Such sampling is also used to identify work areas or individuals with excessive exposure that requires further action. When sampling results are collected by or provided to OSHA or the Mine Safety and Health Administration (MSHA), a valuable database becomes available for surveillance purposes. (See chapter VI in this monograph.)

To estimate worker exposure, NIOSH has conducted direct surveys that use an inventory of workplace products and observations of work practices. (See chapter VII entitled Hazard Surveillance in NIOSH.) Although limited by the lack of direct exposure measurements, these surveys provide a representative sample of potential exposures in US workplaces.

Evaluating the Utility of Surveillance Programs

The Centers for Disease Control has recently developed principles by which surveillance programs can be evaluated.[1] These principles can be applied, with some modification, to surveillance efforts in occupational health.

Efficacy of case identification surveillance programs is best described by quantification of the benefit to the individual case, his or her co-workers, or improvements in the work environment. These benefits can be considered using traditional prevention concepts. Primary prevention will prevent further exposure to the nondiseased. Secondary prevention will prevent progression or result in mitigation of mild disease. Tertiary prevention will lead to rehabilitation or mitigation of more severe disease. In some instances of secondary prevention (e.g., lead toxicity or carpal tunnel syndrome), the adverse effects are at least partially reversible after exposure to the hazardous substance or activity has stopped or after appropriate medical management has been instituted.[11] In other situations (e.g., noise-induced hearing loss or silicosis), progression of disease due to continued exposure is prevented by removing the worker from contact with the offending agent, an example of tertiary prevention. Unfortunately, there are only a few situations where case detection can lead to medical intervention, as in screening for bladder cancer among workers exposed to a bladder carcinogen.

Evaluation of occupational surveillance systems that focus on group results to monitor trends can be performed using general public health principles.[1] Timely reporting of surveillance results is essential if results are to be used to modify control programs. Accurate and representative data must be obtained to ensure the credibility of results. Since trends are to be compared over time and place, consistency of data collection and analysis is essential.

Trends in Surveillance Programs

The limitations in surveillance systems described have been acknowledged by many groups including the National Academy of Sciences[10] and the Congress of the United States.[12] To address these limitations, researchers have over recent years made significant improvements in many aspects of occupational health and exposure surveillance. These positive trends in program development are encouraging and indicate the direction of future work.

Strengthened Morbidity Surveillance

In the past, surveillance systems in occupational health have relied heavily on mortality records. However, since most occupational conditions manifest as nonfatal outcomes, surveillance systems have been developed to focus on morbidity rather than mortality. Of particular importance in this regard are worker surveys, discussed in chapter II of this monograph.

Method Standardization

Questionnaires and diagnostic tests used in surveillance programs are being standardized to improve the reproducibility of survey results, as Ehrenberg and Sniezek point out in chapter III. Case definitions are being developed to standardize provider reporting, as addressed by the authors of chapter V. As standardization improves, reproducibility of results will improve proportionately.

Improved Employer Reporting

OSHA citations of employers for inadequate medical recordkeeping have received national attention and may improve the quality and representativeness of employer-generated health reports. Although of limited utility in disease surveillance, employer reports of injuries provide an important source of surveillance data. Hanrahan and Moll focus on this important concern in chapter VIII.

Strengthened Infrastructure

With NIOSH support and increased activity at the state and local level, the capacity for state health departments to conduct occupational health surveillance has been strengthened. Through such programs as SENSOR, state governments are becoming more actively involved in surveillance. Some states (e.g., New York) have linked surveillance activities to a network of occupational health clinics to provide a more comprehensive approach to prevention. Baker discusses the concept of SENSOR (Sentinel Event Notification System for Occupational Risks) in chapter IV of the monograph, while Welch delineates the role of the networking clinics in chapter XI.

Improved National Surveys

Through collaboration among the various federal agencies (NCHS, NIOSH, and BLS) existing national surveys have been expanded to address occupational health concerns. (See chapter III for details on these collaborative efforts and development of the standard questionnaire for occupational health research.) The 1988 National Health Interview Survey (NHIS) included a substantial supplement on occupational health. The National Health and Nutrition Examination Survey (NHANES), currently in the field, is also collecting data relevant to occupational disorders. Other NCHS surveys provide similar opportunities.

Improved Exposure Surveillance

By targeting specific industries, existing exposure data for the Mine Safety and Health Administration (MSHA) or OSHA are being used to monitor exposure trends. For example, NIOSH analyses of MSHA data on exposure to coal dust in long-wall mining revealed that exposure levels in certain jobs have increased over recent years. Soon after receipt of these analyses from NIOSH, MSHA provided new guidance to compliance officers that will target exposure sources identified through exposure surveillance.

Conclusion

Surveillance in occupational health is a complex process. Programs are performed for a variety of purposes by many groups. No single approach to surveillance is able to address the complex needs of the field of occupational health and safety. Recent improvements in data systems and their use have identified new ways to use surveillance data to prevent occupational disease and injury.

REFERENCES

1. Klaucke DN, Buehler JW, Thacker SB, *et al:* Guidelines for evaluating surveillance systems. MMWR 1988; 37(suppl 5):1–18.
2. Baker EL, Melius JM, Millar JD: Surveillance of occupational illness and injury in the United States: current perspectives and future directions. J Public Health Policy 1988; 9:198–221.
3. Rutstein DD, Mullan RJ, Frazier TM, *et al:* Sentinel health events (occupational): a basis for physician recognition and public health surveillance. Am J Public Health 1983; 73:1054–1062.
4. Foege W: The four premises of public health. The Courier, Atlanta, GA (Emory University) January 8, 1988.
5. Halperin WE, Ratcliffe J, Frazier TM, *et al:* Medical screening in the workplace: proposed principles. JOM 1986; 28:547–552.
6. Wilson JM, Jonger G: Principles and practices of screening for disease. Public Health Papers 1968; No. 34. Geneva: World Health Organization.
7. Yodaikien RE: Surveillance, monitoring, and regulatory concerns. JOM 1986; 28:547–552.
8. Langmuir AD: William Farr: founder of modern concepts of surveillance. Int J Epidemiol 1979; 5:13–18.
9. Muldoon JT, Wintermeyer LA, Eure JA, *et al:* Occupational disease surveillance data sources, 1985. Am J Public Health 1987; 77:1006–1008.
10. National Academy of Sciences: Counting Injuries and Illness in the Workplace: Proposals for a Better System. Washington, DC: National Academy Press, 1987.
11. Levy BS, Wegman DH: Occupational Health. 2nd ed. Boston: Little Brown, 1988.
12. Committee on Government Operations: Occupational illness data collection: Fragmented, unreliable, and 70 years behind communicable disease surveillance. 60 Report by the Committee. House Report 98-1144. Washington, DC: Govt. Printing Office, 1984.

II. Use of Direct Surveys in the Surveillance of Occupational Illness and Injury

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Introduction

The ultimate goal of any public health endeavor is to develop and implement interventions that improve some aspect of modify some determinant of the health and well-being of a population. Successfully achieving this goal requires an accurate assessment of the current status of the problem being addressed, identification of appropriate targets for intervention, and the ability to evaluate results of interventions once they have been introduced. Surveillance plays an important role in this process.[1]

Within the context of occupational health surveillance as described in the preceding paper by Baker, Honchar, and Fine, direct surveys have become increasingly important. A direct survey is defined as the systematic collection of information (whether by questionnaire, examination, or a combination of the two) in a well-defined, firsthand manner from participants selected through a specific sampling procedure to be representative of a larger population. Although this discussion will refer in particular to large, nationwide surveys that are conducted by governmental agencies on a periodic basis, the principles transfer directly to smaller-scale efforts performed by other organizations, including private employers. Direct surveys are effective methods of obtaining surveillance data for many work-related conditions or adverse health events. This is particularly true for conditions that: produce considerable morbidity but little or no mortality (e.g., noise-induced hearing loss, occupational dermatitis, and repetitive trauma disorders); and/or may not be easily recognized as work-related or unambiguously attributed to the workplace (e.g., neurotoxic disorders or non-pneumoconiotic, chronic lung disorders).

Background

In the past, direct surveys have provided useful data for surveillance of occupational illness and injury. NIOSH conducts the National Study of Coal Workers' Pneumoconiosis through the National Coal Study to monitor the incidence and prevalence of this condition among coal miners in several states.[2] Similarly, NIOSH conducted the National Occupational Hazard Survey (NOHS),[3] the National Occupational Exposure Survey (NOES),[3] and the National Occupational Health Survey of Mining (NOHSM),[4] which surveyed worksites rather than individuals to collect data for occupation- and industry-specific hazard surveillance. Finally, NIOSH researchers and others have analyzed data acquired earlier through various nationwide surveys conducted by the National Center for Health Statistics (NCHS) to provide useful information for surveillance of work-related conditions. Examples of surveys employed in this manner include the National Health Interview Survey (NHIS),[5] the National Natality Survey (NNS) (now termed the National Maternal and Infant Health Survey [NMIHS]),[6] and surveys in the National Health and Nutrition Examination Survey (NHANES) series.[7] Although data from these latter surveys have been useful for occupational health surveillance, past procedures for gathering the information were not primarily designed for this purpose.

The National Health Interview Survey (NHIS)[8] is an annual interview survey consisting of a core questionnaire that remains essentially constant from year to year and one or more supplements that are changed annually. The core questionnaire obtains demographic data and information on activity limitations; health care utilization; and the presence, severity, and impact of numerous medical conditions. Each supplement is self-contained (except for routine demographics) and is specifically designed by the sponsoring investigators to obtain detailed information about a particular condition(s) or health-related topic(s). Currently, the entire survey is administered to some 50,000 households (providing data on approximately 130,000 individuals) that are selected through a multistage, probability-sample strategy and are representative of the US civilian, noninstitutionalized population. Since 1985, versions of the survey have incorporated design features intended to facilitate future follow-up of participants and linkage with other national datasets, such as the National Death Index.[9]

The National Health and Nutrition Examination Survey (NHANES) series of nationwide surveys[10] combines questionnaire-derived data with results obtained from batteries of physical and laboratory examinations. Conducted at differing intervals since 1971, these surveys have varied in content, procedures, and methodology. NHANES surveys have examined samples of varying sizes (generally 30–40,000), and (except for one smaller survey directed at the Hispanic population) participants have been selected through methods similar to NHIS as representative of the US civilian, noninstitutionalized population. Past NHANES surveys have not had preplanned, follow-up components, although NHANES I participants were re-evaluated in the NHANES I Epidemiologic Follow-up Survey, performed approximately 10 years later. Planning for NHANES III, which began data collection in October 1988, includes provision for future follow-up on the status of study participants.

Role of Periodic Surveys in Surveillance

Large, periodic surveys offer important opportunities in occupational health surveillance, especially when this application is anticipated throughout survey planning. Although this approach may be criticized as not constituting true surveillance because some surveys are not ongoing, timely, and periodic at regular (or even irregular) intervals, or because they are expensive uses of resources, appropriate planning and careful utilization of resources can address such objections. Even when data are not directly applicable to

NOTE: Author affiliations and addresses are listed on p. 7.

surveillance needs, such surveys are valuable components of an overall, comprehensive surveillance strategy. Specifically, direct surveys can: 1) refine and standardize methodologies to be used elsewhere in obtaining surveillance data; and 2) provide normative or reference ranges for various measures of health status or adverse health effects that are monitored through other surveillance activities.[11]

Better standardization of data-collection tools is needed to improve the quality and applicability of survey results.[12] The process of standardizing methods (whether questionnaire content or examination procedures) includes ensuring that the methods produce results that are consistent, valid, and reproducible gauges of the phenomena they purport to measure. Thus, data collected via standardized methods are inherently more reliable and, all other factors being equal, should provide more accurate estimates of the parameters under investigation. Furthermore, when such standardized approaches are accepted and adopted generally, results from different studies conducted at different times and in different places can be compared meaningfully. Pooling of such standardized data offers several potential benefits, including more precise estimates, greater power to detect low-probability events or weaker associations, and more dependable evaluations of perceived trends over time. The importance of a standard questionnaire for such applications is discussed in chapter III of this monograph.

A second value of direct surveys is their ability to provide normative databases. Lack of reliable reference ranges for many parameters that are monitored in working populations is often a major impediment to research in occupational health. Whether directed toward surveillance purposes, hypothesis generation/confirmation, or targeted interventions (e.g., health hazard evaluations), such studies generally rely on detecting differential effects between exposed and nonexposed worker populations. For many reasons, obtaining a nonexposed comparison group is often difficult.[11] A suitable control group may simply be unavailable because all accessible workers are exposed to some extent to the agent of interest. When nonexposed workers are available, they may have confounding exposures to other agents that have similar effects. Furthermore, nonexposed workers may lack incentives to participate in numbers sufficient to allow valid analysis of the results. Finally, participation by both exposed and nonexposed workers in such focused studies may be subject to considerable selection bias.

Readily available and reliable reference ranges obtained via standardized procedures would help alleviate these deficiencies for both questionnaire-derived information and data obtained from procedures like spirometry or audiometry. The large number of participants in these national studies will also permit more valid compensation for the influence on the various effect estimates by confounders such as smoking, alcohol use, and the presence of other nonoccupational, medical conditions.[13] Finally, such data can also be used as reference or expected values where existing standards require specific forms of periodic testing, and they could help private industries that conduct their own routine screening or surveillance programs to monitor the health of their employees.

Normative databases will thus be available for both the general employed population and the overall adult population. Age-, sex-, and race-specific estimates will be available because of the large sample size. Some further breakdowns may also be possible, such as calculations, when appropriate, of separate reference ranges for "blue collar" and "white collar" populations. In some circumstances, reference estimates may be determined for certain broad industry or occupation categories, although the rapid decrease in cell size with such stratifications will strictly limit this type of analysis. Finally, such information may be linked with specific exposures by merging survey-derived data with a job-exposure matrix, such as that which has been constructed from data obtained in the NOHS and NOES surveys.[14] (Also, see chapter VII in this monograph.) When prevalence rates for specific diseases or conditions can be estimated from survey data, they can be compared with rates produced by other surveillance systems (e.g., workers' compensation data). This will allow better assessment of these other systems, which are subject to under-ascertainment of cases for many reasons, including failure to recognize work-relatedness and various legal or administrative (nonmedical) barriers to workers' compensation systems.

The design of these studies now incorporates improved capacity for follow-up, which offers additional benefits for surveillance activities. Given adequate resources, repeated assessment of the entire survey cohort (or a representative subsample) will identify trends in prevalence rates over time and allow calculation of more precise incidence rates. It will also help to identify the characteristics that best serve as predictors of future disease (i.e., identify high-risk populations in greatest need of direct interventions). Specific subpopulations of survey participants can also be selected for follow-up. Individuals known to have conditions of interest can be resurveyed to improve understanding of the progression and natural history of these conditions and of their consequences (e.g., social and economic). Analyses can also be performed to compare the course of disease among exposed and nonexposed participants.

Specific Future Plans

To improve the value of direct national surveys for occupational health surveillance, NIOSH and NCHS have collaborated to include occupational health sections in the 1988 NHIS survey and as components of the current NHANES III survey.[15] The conditions proposed for inclusion in these surveys were selected using several criteria:

- The conditions were to be relatively frequent so that a sufficient number of cases for meaningful analysis could be expected in the survey population.
- A relatively high risk-percentage of these conditions should be attributable to the workplace. In general, the conditions were selected from the NIOSH list of 10 leading work-related diseases and injuries.[16]
- The target conditions were to be relatively amenable to currently available preventive strategies.
- For NHIS, the conditions must be able to be reliably diagnosed by reporting of symptoms and/or by other questionnaire-derived information. For NHANES, the conditions must be diagnosable through a combination of questionnaire-derived information and data obtained from relatively simple and readily available examination procedures (which are suitable for field use).

The 1988 NHIS included an Occupational Health Supplement with sections that provide detailed investigation of occupational history (current and longest-held jobs); back pain; hand discomfort (related to repetitive trauma disorders like carpal tunnel syndrome); work-related acute injuries;

occupational dermatitis; mucosal irritations of the eye, nose, and throat; and a final section (designed in collaboration with the Bureau of Labor Statistics) briefly investigating the presence and consequences of several potentially work-related conditions, such as tendonitis, hepatitis, and chronic bronchitis.* NHANES III, which began field operations in October 1988, includes a questionnaire section on occupational history (current and longest-held jobs) and questionnaire/examination modules that address respiratory conditions and work-related neurotoxicity. Additional data will be obtained on a variety of biologic exposure markers and biochemical measures of health status. On completion, both surveys are expected to provide valuable data that are directly and indirectly applicable to the surveillance of occupational illness and injury.

Conclusions

Direct surveys provide important opportunities to obtain health information on individuals that cannot be collected in other ways. Surveys are particularly useful in ascertaining the prevalence of conditions that manifest as morbidity rather than mortality and that can be detected by survey questionnaire or diagnostic tests. Large national surveys provide further opportunities to standardize methods to be used in smaller surveillance projects directed at defined exposed populations and to create reference values for comparison with the results of these smaller studies.

*Questionnaire content is available from the author or from NCHS.

REFERENCES

1. Langmuir AD: The surveillance of communicable diseases of national importance. N Engl J Med 1963; 268:182–192.
2. Attfield M, Reger R, Glenn R: The incidence and progression of pneumoconiosis over nine years in US coal miners: I. Principal findings. Am J Indust Med 1984; 6:407–415.
3. Seta JA, Sundin DS: Trends of a decade—a perspective on occupational hazard surveillance, 1970–1983. *In:* Centers for Disease Control: Surveillance Summaries, 1985. MMWR 1985; 34:(2SS):15SS-24SS.
4. Groce DW, Carr WGA, Hearl FJ: The National Occupational Health Survey of Mining. *In:* Centers for Disease Control: CDC Surveillance Summaries, 1986. MMWR 1986; 35(2SS):17SS-24SS.
5. Centers for Disease Control: Self-reported hearing loss among workers potentially exposed to industrial noise—United States. MMWR 1988; 37:158–167.
6. Makuc D, Lalich N: Employment characteristics of mothers during pregnancy. Health: United States 1983. DHHS Pub. No. (PHS) 84–1232. Washington, DC: Govt Printing Office, 1983.
7. Centers for Disease Control: Results of blood lead determinations among workers potentially exposed to lead—United States. MMWR 1983; 32:216–219.
8. Moss AJ, Parsons VL: Current estimates from the National Health Interview Survey, United States, 1985. Vital and Health Statistics, Series 10, No. 160. Washington, DC: NCHS, 1986.
9. Patterson BH, Bilgrad R: Use of the National Death Index in cancer studies. JNCI 1986; 77:877–881.
10. McDowell A, Engel A, Massey JT, Maurer K: Plan and operation of the second National Health and Nutrition Examination Survey, 1976–80. Vital and Health Statistics, Series 1, No. 15. Washington, DC: NCHS, 1981.
11. Schulte PA, Singal M, Stringer WT, *et al:* The efficacy of a population-based comparison group in cross-sectional occupational health studies. Am J Epidemiol 1982; 116:981–989.
12. Baker EL, Melius JM, Millar JD: Surveillance of occupational illness and injury in the United States: current perspectives and future directions. J Public Health Policy 1988; 9:198–221.
13. Brackbill R, Frazier T, Shilling S: Smoking characteristics of US workers, 1978–1980. Am J Ind Med 1988; 13:5–41.
14. Seiber WK, Sundin DS, Young RO: Development of job-exposure matrix. *In:* The changing nature of work and workforce. Proceedings of the 3rd joint US—Finnish Science Symposium, 1986; 31–34. Pub. No. PB-87–189–304. Springfield, VA: National Technical Information Service, 1986.
15. Wagener DK, Buffler PA, Cohen BB, Rosenberg HM: National information on occupational health: a guide to the NCHS data systems. Public Health Rep (in press).
16. Centers for Disease Control: Leading work-related diseases and injuries—United States. MMWR 1983; 32:24–26,32.

III. Development of a Standard Questionnaire for Occupational Health Research

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Desirability of a Standard Questionnaire

The use of nationwide direct surveys is discussed by Ehrenberg in the previous chapter. Information from these surveys can be used to target prevention programs and can provide the normative or reference data for comparison with the results from smaller studies.

Direct worker surveys usually collect health history information using a questionnaire. In addition to questionnaires, certain tests of organ-system function (e.g., audiometry, spirometric pulmonary function testing, and collection of blood or urine specimens) are commonly performed. Newer techniques such as computerized neurobehavioral testing have also been introduced into common use.[1] For many of these outcome variables, as for questionnaires, standard methods or protocols for the collection of data do not exist or have not received general adherence.

A standard questionnaire consists of a set of predetermined questions presented in a specific, unvarying order, which provides strict control over interviewer behavior.[2] Without such standardized methods, variation occurs both within and between studies because of differences in questionnaire content or format and differences in interviewer technique.[3] Unfortunately, most epidemiologic surveys that focus on specific morbid conditions in the workplace, whether performed by NIOSH, other government agencies, or other occupational health researchers, have not utilized a consistent standard questionnaire approach. Consequently, data obtained from separate surveys cannot be easily pooled, or even reliably compared. A standard questionnaire is being developed by NIOSH to facilitate the reproducibility of data collection and the pooling or comparison of data obtained from different surveys so that direct worker surveys can be used as a form of health surveillance among exposed populations.

Development of a Questionnaire and Its Intended Use

Several issues must be considered in developing such a standard questionnaire. First, the purpose of the questionnaire should be clearly specified. In the case of the NIOSH standard questionnaire, the questionnaire is seen as an essential tool in establishing among respondents the presence or absence of selected occupational diseases or work-related disorders (as defined by the World Health Organization[4]). Specific classes of conditions (Table 1) were selected, in part, because self-reported information can, in most circumstances, provide reasonably reliable indication of their presence. Furthermore, interviewees can provide meaningful, detailed information on the circumstances of certain important health events (such as acute traumatic injuries) in the recent past.

In addition to a history of specific medical symptoms and adverse health events, the questionnaire will provide important information on relevant demographic characteristics and personal habits that might act as independent risk factors, effect modifiers, or confounding factors in the development of occupational diseases or work-related disorders.[5] Finally, the questionnaire will be used to obtain a relevant occupational history including current and past occupation and industry and the potential for exposure to certain key, identifiable workplace hazards.

Experience with the use of previous standardized questionnaires has demonstrated the importance of specifying the intended purpose for such an instrument to avoid use in inappropriate situations. The large number of potential applications and users of a standard occupational health questionnaire makes this specification particularly important. The questionnaire to be described here is intended primarily for use in: 1) periodic medical evaluations of workers perceived to be at risk as a result of occupational exposures or hazards; and 2) group assessments of workers who participate in etiologic investigations such as epidemiologic studies or Health Hazard Evaluations (HHEs).

With respect to the first application, private industries often perform screening activities in which employees receive periodic medical evaluations; some of these are directed at detecting particular work-related conditions or outcomes, while others are more general. In some instances these periodic evaluations are mandated by regulatory agencies (e.g., the periodic monitoring of workers exposed to lead, cotton dust, and asbestos as prescribed in OSHA regulations). A standard questionnaire used for such routine screening might require minor modifications so that two instruments are used, one to obtain a broad set of baseline data and a second (generally briefer and more focused) to be administered subsequently to elicit interval changes in status.

Although etiologic investigations often consist of cross-sectional medical evaluations without subsequent follow-up, data from separate studies could be pooled through use of a standard questionnaire. Follow-up evaluations of the same population are greatly facilitated by repetitive use of a standard questionnaire.

The current questionnaire is not designed as a diagnostic tool for the clinical assessment of individual workers. The degree of sensitivity and specificity required to make indi-

NOTE: Author affiliations and addresses are listed on p. 7.

TABLE 1—Questionnaire Structure

I. Demographics
II. Occupational History
III. Brief Review of Systems and Past Medical History
IV. Personal Risk Factors and Environmental History
V. Conditions/Symptom-Complex Modules
  a. Dermatoses
    Irritative contact dermatitis, allergic contact dermatitis, defatting dermatitis, chloracne, and eczema.
  b. Mucosal irritations of the eyes, nose, and throat
    Mucosal and upper airway irritation and allergic responses associated with chemical agents and biologic agents.
  c. Respiratory disorders
    Chronic bronchitis, emphysema, asthma, chemically induced pulmonary edema, chemical pneumonitis, hypersensitivity pneumonitis, pneumoconiosis (e.g., silicosis, asbestosis, coal workers' pneumoconiosis, byssinosis), metal fume fever, and respiratory tract malignancies.
  d. Cardiovascular disorders
  e. Disorders associated with hepatotoxins
    Jaundice and chemical hepatitis.
  f. Renal diseases
    Kidney stones, glomerulonephritis, and tubular disorders.
  g. Musculoskeletal disorders
    Low back pain syndrome (associated with sprains, strains, disc pathology, arthritis and degenerative joint disease). Repetitive trauma disorders of the hand/wrist (to include carpal tunnel syndrome, ulnar nerve compression, De Quervain's disease, degenerative joint disease/arthritis, trigger finger, and tenosynovitis).
  h. Neurotoxic disorders
    Peripheral neuropathy, toxic encephalopathy, and seizure disorders.
  i. Noise-induced hearing loss
    Noise-induced hearing loss/deafness and Meniere's syndrome.
  j. Psychologic disorders
  k. Infertility and adverse reproductive outcomes
    Diminished fertility, spontaneous abortions, tubal pregnancies, stillbirths, prematurity/low birthweight, birth defects, mental retardation, and childhood cancers.
  l. Acute injuries
    Amputations, contusions, fractures/dislocations, lacerations, sprains, electric shocks, and effects of physical agents.

vidual diagnoses (on which to base treatment plans, for example) exceeds that needed for group assessments and would require detail that is impractical for an epidemiologic instrument. Standard questionnaire instruments may well be useful and desirable for this and other situations and would entail considerable overlap of question content, but the different use necessitates sufficiently different instruments so that no single questionnaire could adequately serve in all circumstances.

Finally, the manner of administering the questionnaire (i.e., self-administered versus interviewer-administered), the length of the questionnaire, and the structure and organization of the questionnaire are also relevant to appropriate application or use of the questionnaire. The current questionnaire is being developed as an interviewer-administered instrument and has a modular construction that incorporates a set of core questions for use in all administrations and a set of modules to be selected and employed as needed. This structure allows the investigator to adapt the questionnaire depending on time constraints, circumstances, and needs. Present modules are based on organ systems or on conditions associated with work-related problems (Table 1). Ultimately, exposure-based modules will be developed for use with workers who are exposed to selected specific agents (e.g., pesticides, solvents, or certain heavy metals) that produce toxic effects manifest in multiple organ systems.

Rationale for Inclusion of Conditions

A high priority for development of a module was assigned to conditions if they met the following criteria:

1. The condition or symptoms occur relatively frequently.
2. The attributable risk percentage of the condition or symptoms related to the workplace should be relatively high.
3. The presence (and severity) of the condition or symptoms should be readily and reliably identified using only questionnaire-generated data. It is recognized, however, that in many circumstances the questionnaire would be used in conjunction with diagnostic tests (e.g., pulmonary function tests, blood specimens, etc.).
4. With certain exceptions, the condition should appear on the NIOSH list of the 10 leading work-related diseases and injuries.[6] Although mucosal irritation of the eye, nose, and throat does not appear on the list of the 10 leading work-related diseases and injuries, these symptoms are included because they are extremely common complaints that are encountered frequently in NIOSH Health Hazard Evaluations and workplace investigations conducted by other researchers.
5. The condition should be perceived in the occupational health community as of relatively high importance.
6. The potential benefit of a NIOSH standard set of questions should be relatively great for research into the condition.

List of Target Conditions

The following 10 categories of work-related conditions to be included in the proposed questionnaire (Table 1) were chosen according to the rationale presented in the previous section, with particular attention paid to the NIOSH list of 10 leading work-related diseases and injuries and the list of sentinel health events (occupational).[7] The modules cover: 1) dermatologic conditions, 2) mucosal irritation of the eye, nose, and throat, 3) respiratory disorders, 4) hepatic conditions, 5) renal conditions, 6) musculoskeletal disorders, 7) neurotoxic disorders, 8) noise-induced hearing loss,

9) adverse reproductive outcomes, and 10) work-related injuries. In addition, modules will be created that address work-related cardiovascular disorders and work-related psychologic disorders.

Source of Questions

When possible, previously standardized or established questionnaires were used as starting points for the creation of modules and as sources of questions. The American Thoracic Society (ATS) Adult Questionnaire[8] was recommended for use because it is considered the standard for addressing respiratory symptoms. Minor modifications have been made in utilizing the ATS questionnaire to facilitate ease of questionnaire administration and to expand the information collected on asthma and other acute respiratory conditions. A set of ancillary questions is included to collect additional information on other specific respiratory conditions.

The Gallaudet Scale, a questionnaire instrument developed to assess functional hearing loss, is included because of its usefulness when audiometric testing is not practical or available. It has been well standardized[9] and was administered in the National Health Interview Survey in 1971 and 1977; these data have already contributed to occupational health surveillance.[10]

The section on the nervous system derives, in part, from a questionnaire developed in Sweden by Hogstedt, *et al*, to assess the prevalence of solvent-related symptoms in exposed workers.[11] This questionnaire was modified in research performed at Harvard University to adapt it to the American worker population and to include symptoms of peripheral nervous system dysfunction.[12]

For other portions of the questionnaire, when generally accepted models did not exist, the results of NIOSH research, additional questions derived directly from NIOSH investigations such as Health Hazard Evaluations and industry-wide studies, and the expertise of NIOSH Committee members were used.

Future Work

Although the basic content of each module has been established, several further stages of questionnaire development remain. These include: 1) refining of individual questions, 2) deciding on the final format of the instrument, and 3) pretesting and field-testing the questionnaire. When appropriate, input will be sought from other subject matter experts and interested parties, such as the relevant professional associations.

First, the layout and wording of individual questions will be refined to improve readability and comprehensibility and to minimize potential for bias introduced by the wording of questions. Next, the question formats must be specified to ensure that similar types of information are elicited consistently in different modules. This specification will also assure consistency in the time frames considered, the choice of whether to elicit open-ended or pre-categorized answers, and the scaling of responses. Finally, questionnaire components will require pretesting and field-testing before final publication. This process will address the degree of understanding subjects have regarding what is being queried (and whether their understanding matches the intentions of the investigators), the reliability and reproducibility of answers to the questions, and the validation of answers. To evaluate the questionnaire's specificity, assessments based on questionnaire results will be compared with what would be predicted for test subjects according to current understanding of the relevant condition, as gleaned from current scientific literature (i.e., does a group known to have a certain exposure demonstrate the effects that would be expected from such exposure?).

After the questionnaire has been made final, an interviewer's guide, comparable to that developed for the ATS questionnaire, will be developed for the questionnaire and its component modules. This document will help members of the occupational safety and health community use the questionnaire easily and appropriately.

Summary

Direct surveys of groups of workers can provide valuable occupational health surveillance data, but this requires consistent collection of data. As part of efforts to improve the standardization of such methodology, NIOSH is developing a standard occupational health questionnaire. This questionnaire will be designed to collect demographic and occupational history information in addition to information about the presence of a spectrum of work-related conditions. The questionnaire will have a modular structure and will consist of a core questionnaire and a series of condition-specific modules.

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REFERENCES

1. Baker EL, Letz R: Neurobehavioral testing in monitoring hazardous workplace exposures. JOM 1986; 28:987–990.
2. Samet JM: An historical and epidemiologic perspective on respiratory symptom questionnaires. Am J Epidemiol 1978; 108:435–446.
3. Stolley PD, Schlesselman JJ: Planning and conducting a study. *In:* Schlesselman J: Case-Control Studies, Design, Conduct, Analysis. New York: Oxford University Press, 1982.
4. World Health Organization Expert Committee: Identification and Control of Work-Related Diseases. Geneva: World Health Organization, 1985.
5. Hernberg S: Working Document No. 1: Epidemiological Study of Work-Related Diseases. Joint ILO/WHO Committee on Occupational Health Working Group. Geneva: World Health Organization, September 1987.
6. Centers for Disease Control: Leading work-related diseases and injuries—United States. MMWR 1983; 32:24–26, 32.
7. Rutstein DD, Mullan RJ, Frazier TM, *et al:* Sentinel health events (occupational): a basis for physician recognition and public health surveillance. Am J Public Health 1983; 73:1054–1062.
8. Ferris BG: Epidemiologic Standardization Project (American Thoracic Society). Am Rev Respir Dis 1978; 118(No. 6 Part 2):1–120.
9. National Center for Health Statistics: Development and evaluation of an expanded hearing loss scale questionnaire. Vital and Health Statistics, Series 2, No. 37. PHS Pub. No. 1000. Washington, DC: Govt Printing Office, April 1970.
10. Centers for Disease Control: Self-reported hearing loss among workers potentially exposed to industrial noise—United States. MMWR 1988; 37:158, 164–167.
11. Hogstedt C, Andersson K, Hane M: A questionnaire approach to the monitoring of early disturbances of central nervous functions. *In:* Aitio A, Rihimaki V, Vainio H (eds): The Biologic Monitoring of Exposure to Industrial Chemicals. Washington, DC: Hemisphere Publishing Corporation, 1984.
12. Fidler AT, Baker EL, Letz RE: Neurobehavioral effects of exposure to organic solvents among construction painters. Br J Ind Med 1987; 44:292–308.

IV. Sentinel Event Notification System for Occupational Risks (SENSOR): The Concept

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Introduction

As Langmuir[1] and Foege and colleagues[2] have discussed, the purpose of surveillance is not only to collect and analyze data but also to direct active prevention programs designed to control and, when possible, eliminate the occurrence of preventable disorders. In the past, several states have enacted specific laws and regulations requiring physicians, laboratories, and other health care providers to report selected occupational diseases.[3] Although in a few states the development of targeted reporting systems has been linked with case follow-up and workplace intervention from the beginning,* in most instances, state programs for provider reporting of occupational conditions have not, unfortunately, been linked with response and intervention efforts.

Other shortcomings have also been identified that have limited the usefulness of provider-reporting systems.[4] These include uncertainty among providers about characteristics of specific occupational disorders (i.e., lack of epidemiologic case definitions). In the reporting of communicable diseases, on the other hand, the development of case definitions has greatly facilitated the epidemiologic investigation of selected conditions.[5] Another limitation of existing reporting systems for occupational disease is the lack of formal, defined networks of sentinel providers with specific responsibility for reporting selected conditions to state health agencies. Although the regulations in many states specify that any occupational disease should be reported, inadequate guidance has been provided to practitioners on how to carry out such reporting. Finally, the resources to receive, analyze, and direct responses to reported cases are minimal or lacking in most states.

Overview

To address these limitations, 10 states have initiated targeted provider-reporting systems, called collectively the Sentinel Event Notification System for Occupational Risks (SENSOR), to perform active surveillance of selected occupational conditions. These SENSOR systems build on the experience and capacity already present in state health and labor departments, which were, in part, previously developed with NIOSH support.

In its original concept, the SENSOR system consists of two organizational components (Figure 1). First, a network of sentinel providers (e.g., individual practitioners, laboratories, and/or clinics) is identified in each state system. This provider network recognizes and reports cases of the selected occupational disorders to the surveillance center. The center receives reports from and interacts with the providers, analyzes the data, and directs intervention activities toward the individual cases, co-workers, and the worksites from which cases are reported. The center is also responsible for handling confidential medical data properly and for determining appropriate and effective intervention procedures. Besides fulfilling this pivotal role of coordinating responses to provider reports, the center may also provide technical consultation or more substantive action on a wide variety of occupational health issues (e.g., use of vital records and other existing data sources for monitoring trends of occupational disorders, disseminating information, etc.). In most states where the health and labor departments share responsibilities in occupational health and safety, the surveillance center is expected to facilitate interaction between complementary programs that may currently exist in relative isolation.

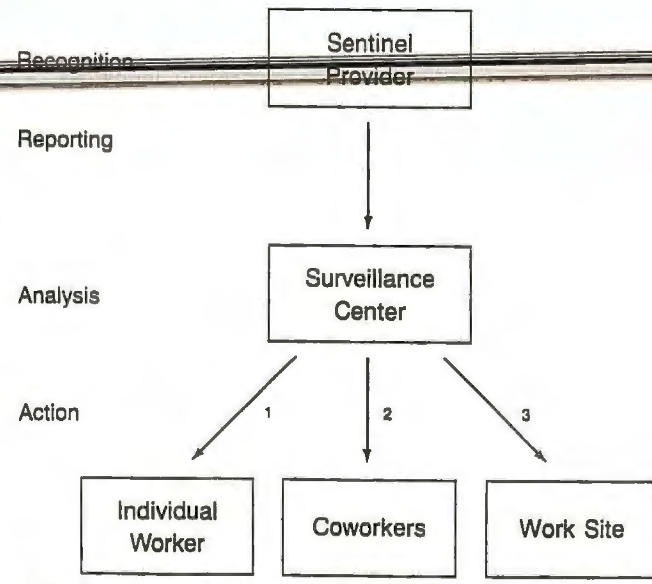

FIGURE 1—Organizational Components of SENSOR

In most instances, this center is located in the state health department. The surveillance center is responsible for: maintaining targeted reporting activities (including case finding); following up reported cases (including case confirmation); screening for the disorder in other workers at the site; evaluating worksite factors potentially responsible for the disorder; issuing workplace-specific recommendations for hazard abatement; and developing and maintaining other appropriate and possible activities related to occupational illness and injury (e.g., trend analysis, education, technical consultation, information dissemination).

Recognition

To facilitate the recognition by sentinel providers of

NOTE: Author affiliations and addresses are listed on p. 7.

*Honchar PA, Martin J: Development of surveillance and intervention for lead-exposed workers in Texas: preliminary results (in preparation).

selected occupational conditions, NIOSH has limited the initial scope of the program and identified six conditions (silicosis, occupational asthma, pesticide poisoning, lead poisoning, carpal tunnel syndrome, and noise-induced hearing loss) that lend themselves with comparative ease to provider reporting. The criteria for selection of conditions are discussed in chapter V of this monograph. Depending on local evaluations of occupational risks, which vary from state to state, the surveillance centers can also propose other conditions for reporting.

Besides helping to identify conditions for reporting and follow-up, NIOSH is also completing a set of reporting guidelines for the selected conditions to help practitioners recognize possible cases, and a set of epidemiologic case definitions for the centers to use in counting and summarizing reported cases and in assessing the need for follow-up investigation. These guidelines and definitions will improve provider awareness and understanding of the selected occupational conditions and encourage uniform reporting among participating states. Ultimately, analyses of case reports will provide useful information about the characteristics of selected occupational conditions, their sequelae, and other important clinical and epidemiologic features.

Reporting

Providers usually report cases to state health departments by telephone or mail, using forms developed by the requesting agency. Recent advances in computer technology and telecommunication techniques now provide more efficient and rapid alternatives for transferring this information.[6] NIOSH is facilitating a more interactive transmission of data from providers to surveillance centers by supporting the development of computer technology that allows electronic transmission of data for analysis and response.

The absence of immediate capabilities for electronic transmission of case reports is not, however, delaying or deterring the development of targeted reporting systems. The surveillance centers interact directly with sentinel providers in all current projects to encourage the recognition and reporting of occupational cases.

Analysis

Staff epidemiologists, statisticians, and other occupational health professionals in the surveillance centers analyze case reports from the provider network and determine whether further case follow-up and action are appropriate. In addition, they prepare summaries of reported cases and responses for distribution, especially to the sentinel providers who have reported the cases. In many states, the results of such analyses can be disseminated through publications directed at public health professionals, physicians, and other professionals. The results of such analyses can often be appropriately included in such CDC publications as the *Morbidity and Mortality Weekly Report (MMWR)*.

Although the data from SENSOR projects are primarily useful for case identification and follow-up, they are also valuable as supplements to other data sources currently used within the states to monitor trends in the occurrence of selected occupational disorders.[7]

Action

Active response and intervention are the heart of the SENSOR concept. Three activities can follow the receipt of a confirmed case report. First, health officials contact the individual who sustained the disorder and offer an intervention to improve health or retard disease progression. (See chapter I in this monograph.) As SENSOR projects develop further, case-management guidelines will be provided to practitioners who report these cases. The second action is directed toward co-workers who are often at risk for developing similar occupational disorders because of common workplace exposures. The screening of co-workers is often appropriate to detect early, potentially reversible health disorders. Finally, in response to reports of individual cases, the surveillance center can coordinate and/or carry out interventions directed at specific causes in the workplace. In view of the current variability in state programs for controlling occupational safety and health hazards, local resources should be considered and used to determine the most appropriate mechanisms for directing such worksite action.

Conclusion

Mandates for provider-reporting systems have existed in several states for many years, but various shortcomings have prevented the potential of targeted surveillance and follow-up for occupational illness and injury from being realized. To achieve a more uniform, active approach to provider reporting, SENSOR was created as a cooperative, state-federal effort to develop local capability for recognizing, reporting, following up, and preventing six selected occupational disorders. NIOSH funded 10 SENSOR projects in late 1987 and early 1988 to demonstrate the feasibility of this approach. Ultimately, joint state-federal support will be essential for maintaining SENSOR activity within the states.

SENSOR should not be viewed as the sole approach for surveillance of occupational illness and injury. Other approaches for identifying cases of occupational illness or injury and for monitoring trends in the occurrence of these disorders will continue to function as components of the overall NIOSH plan for improving surveillance in occupational health and safety.[7] The development of SENSOR is expected to be a significant milestone toward realizing a comprehensive surveillance system for occupational disease and injury in the United States.

Summary

Although many states have laws that require health providers to report cases of occupational illness and injury, most states do not maintain a comprehensive system that actively identifies and targets potential sources of case reports and then responds to such reports. NIOSH has

TABLE 1—SENSOR States and Target Conditions, 1988

State	Silicosis	Occupational Asthma	Pesticide Poisoning	Lead Poisoning	Carpal Tunnel Syndrome	Noise-Induced Hearing Loss
California			X		X	
Colorado		X				
Massachusetts		X			X	
Michigan	X	X				
New Jersey	X	X				
New York				X		
Ohio	X					
Oregon			X			
Texas			X	X		
Wisconsin		X			X	

developed a Sentinel Event Notification System for Occupational Risks (SENSOR) that uses targeted sources of sentinel providers to recognize and report selected occupational disorders to a state surveillance center.

SENSOR is a cooperative state-federal effort designed to develop local capability for preventing selected occupational disorders. To demonstrate the feasibility of this approach, NIOSH initially funded seven SENSOR projects in 1987 and three additional projects in early 1988 (Table 1).

Currently, these projects are in the preliminary stages of organization and start-up, with some having begun to receive case reports. As funds become available, NIOSH intends to gradually expand the scope of the program to include additional states over the next several years.

REFERENCES

1. Langmuir AD: William Farr: founder of modern concepts of surveillance. Int J Epidemiol 1976; 5:13–18.
2. Foege WH, Hogan RD, Newton LH: Surveillance projects for selected diseases. Int J Epidemiol 1976; 5:29–37.
3. Muldoon JT, Wintermeyer LA, Eure JA, *et al:* State activities for surveillance of occupational disease and injury, 1985. *In:* Centers for Disease Control: CDC surveillance summaries, 1987. MMWR 1987; 36:(2SS):7–12.
4. Thacker SB, Choe K, Brachman PS: The surveillance of infectious diseases. JAMA 1983; 249:1181–1185.
5. Thacker SB, Redmond S, Rothenberg RB, *et al:* A controlled trial of disease surveillance strategies. Am J Prev Med 1986; 2:345–350.
6. Graitcer PL, Thacker SB: The French connection. (editorial) Am J Public Health 1986; 76:1285–1286.
7. Baker EL, Melius JM, Millar JD: Surveillance of occupational illness and injury in the United States: current perspectives and future directions. J Public Health Policy 1988; 9(2):198–221.

V. The Selection and Definition of Targeted Work-Related Conditions for Surveillance under SENSOR

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Introduction

Current efforts to prevent work-related illness in the United States are hampered by a lack of adequate systems for monitoring the occurrence of, and targeting interventions for, occupational diseases of public health importance.[1] As part of an overall strategy to improve surveillance of occupational illness and injury in this country,[2] a conceptual model for active occupational disease surveillance based among health care providers is described in chapter IV of this monograph. This proposed system (SENSOR) is intended to serve as a model for state-based programs.

As part of this initiative, the National Institute for Occupational Safety and Health (NIOSH) is recommending that each participating state target a selected list of work-related conditions that are important problems in the state and that are appropriate for surveillance under the SENSOR model. NIOSH has developed a list of work-related conditions that are of public health importance and that will be appropriate for targeting in many state-based SENSOR systems. For these conditions, NIOSH is developing surveillance case definitions for use by state health departments to facilitate standardized data collection and to assist in setting priorities for follow-up of individual case reports. In addition, NIOSH is recommending adapting case definitions for use as educational reporting guidelines to assist providers in recognizing and reporting suspected cases of occupational illness. In this chapter, three appendices illustrate this NIOSH approach for one target condition, work-related carpal tunnel syndrome (see Appendices I, II, and III).

This chapter focuses on the historic role of the Centers for Disease Control (CDC) and the current role of NIOSH in targeting conditions for surveillance, the criteria for selecting target conditions for SENSOR, and the rationale and proposed uses of epidemiologic case definitions.

Selecting Target Conditions

There are three principal reasons for recommending a list of conditions to target for surveillance under SENSOR. First, it is desirable to focus the efforts of SENSOR projects on certain conditions that lend themselves to worksite intervention activities.

Second, a defined list will clarify reporting requirements for providers and foster increased recognition and reporting. Just as a lack of knowledge about what conditions are reportable may explain some underreporting of communicable diseases by physicians,[3] a vague encouragement to report "any occupational disease" may not be sufficient guidance for potential reporters.

A third rationale for recommending a list of target conditions for SENSOR is to promote state-based surveillance of occupational health problems of national importance. In its efforts to monitor the occurrence of selected communicable diseases nationally, CDC has recognized that national surveillance data must come from local and state health officials who can mobilize resources for timely investigations of individual cases (where appropriate) and apparent outbreaks. A recommended national list of notifiable diseases has helped to address national surveillance priorities while maintaining the autonomy of state-based surveillance systems. Accumulation of representative national data is not a primary, short-term objective of the SENSOR proposal. However, success in case recognition and intervention for specific occupational diseases may improve recognition and reporting to the extent meaningful trends can be monitored for reportable conditions. It is, therefore, important to examine the traditional role of CDC in selection of notifiable diseases to understand how the list of conditions targeted for surveillance under SENSOR relates to that role.

The determination of which diseases should be reported to CDC has been the responsibility of state and territorial epidemiologists since 1951. During the annual national meeting of the Council of State and Territorial Epidemiologists (CSTE), proposals for changing morbidity reporting and surveillance practices in states are considered and, in some cases, endorsed by CSTE. Proposals may include revisions to the list of diseases that should be reported to CDC. CDC's role in this process has been to recommend changes in the reportable list based on changing national needs.[4] This process has had some success in achieving a balance between national public health priorities and differing state situations with respect to endemic diseases, public health law, and

NOTE: Author affiliations and addresses are listed on p. 7.

resource availability.

As the institute within CDC charged with promoting occupational safety and health, NIOSH has assumed this role of promoting surveillance for occupational diseases. A 1984 NIOSH proposal to CSTE for a state-based pilot reporting system for silicosis, asbestosis, and coal workers' pneumoconiosis was in keeping with this role. Additional recommendations to the states will result from NIOSH review of state projects that include SENSOR-type surveillance systems as well as that of states using various existing data sets and more traditional, provider-reporting systems. Recommendations to the states may include what conditions to target for surveillance efforts and what methods work best for different types of work-related health problems. Because SENSOR pilot projects may have implications for future recommendations by NIOSH to state health departments, national occupational health priorities were considered in developing the initial list of target conditions for SENSOR.

The criteria used to select the initial list of target conditions for SENSOR will be used to revise and expand the list on an ongoing basis. These criteria are as follows:

- The work-related condition should be one of national public health importance, based on its frequency of occurrence and severity. In this regard, the 1990 objectives for the nation[5] and the 10 leading work-related illnesses and injuries[6] were considered in choosing conditions. Conditions meeting this criterion are also likely to be perceived as important by clinicians.
- The condition can be attributed to work on an individual basis with reasonable reliability, based on current knowledge. Some conditions, such as silicosis, meet this criterion because their clinical manifestations are usually sufficiently unique to distinguish them as work-related. For certain systemic poisonings, as with lead or pesticides, a reliable laboratory test is available to establish the presence of hazardous levels of a toxicant, such levels being most often due to exposure at work. Another class of occupational illnesses may not have manifestations or laboratory findings that distinguish them as work-related, but may be attributable in the presence of an appropriate exposure history. An example of such a condition would be work-related carpal tunnel syndrome (CTS). Although work-related cases of CTS may have the same signs and symptoms as non-work-related cases, certain manual tasks are associated with a high relative risk (hence a high attributable risk percentage) for this condition. In the presence of an appropriate occupational history, then, such cases can be attributed to work with sufficient confidence for surveillance purposes.
- Priority should be given to surveillance of conditions with short to medium latencies. Such conditions are likely to be recognized at a time when workplaces where exposures occurred are still operational and causal exposures are still present. However, for some conditions (e.g., silicosis), hazardous workplace conditions may persist even though the exposures contributing to the case at hand occurred many years earlier. Thus, in areas of the country where old, inadequately controlled facilities exist, detection of conditions with a relatively long latency may be useful in targeting workplaces that require focused control efforts.
- Conditions not under surveillance through other data sources should receive priority for provider-based reporting. For example, occupational asthma may be recognized and treated by a physician without resulting in a hospitalization, death, or compensation claim; thus, provider reports of this condition will provide data not obtainable from other sources.
- Conditions that are potentially reversible should receive higher priority for surveillance since control of exposure will benefit both the reported case and co-workers.
- Availability of a feasible preventive strategy should be considered in choosing conditions for reporting. Workplace or work practice changes useful in reducing the risk of certain occupational diseases (e.g., lead poisoning) are well established. Identification of cases of such conditions will be relatively more useful than identifying cases of conditions (such as stress-related symptoms) for which preventive strategies are more complex or difficult to implement.

These criteria were used to develop an initial list of target conditions: occupational asthma, lead poisoning, acute pesticide poisoning, silicosis, work-related carpal tunnel syndrome, and noise-induced hearing loss. Additional conditions will be identified using a similar process. Some of the target conditions will not meet every criterion, but will be high priorities when all criteria are weighed. We anticipate that state surveillance programs will identify additional conditions that meet the above criteria and have particular importance in their states.

The use of a reportable disease list should not preclude providers from less formal reporting of suspicious disease clusters, symptoms, or exposures. Indeed, the infectious disease surveillance experience suggests that an important by-product of reporting notifiable conditions is the informal network it creates between providers and public health officials. Thus, the SENSOR concept has a potential, though secondary, role in identifying new causes of occupational illness.

Epidemiologic Case Definitions and Reporting Guidelines

Purpose of Case Definitions

The central importance of nomenclature in monitoring disease occurrence was recognized by William Farr, the "founder of modern concepts of surveillance."[7] Operational definitions help to focus surveillance efforts and facilitate reliable monitoring of geographic and temporal patterns of disease. Case definitions are also essential for interpretation and dissemination of surveillance data. In this country, changing criteria for defining endemic malaria cases played a key role in recognizing that endemic malaria had disappeared from the southern states, probably before a DDT spraying program had begun.[8] A 1984 survey of state epidemiologists showed substantial variations in case definitions used for reportable diseases and revealed that nearly all state epidemiologists would find standardized case definitions useful in their surveillance efforts.[9] In a proposed approach to evaluating an existing surveillance system,[10] stating the case definition(s) for the health event(s) under surveillance is listed as an early step in the process.

In considering potential sources of occupational disease data, Rose[11] points out that, in current provider-reporting laws, much interpretation and decision-making about what constitutes an occupational disease is left up to the physician.

He implies that this may account for the fact that many such laws are considered inoperative. Some of the strategies developed by NIOSH and the Association of Schools of Public Health for occupational illness and injury prevention[12,13] have recognized the importance of standard case definitions, and a proposed comprehensive plan for national surveillance of occupational diseases[2] lists the development of standard case criteria as a major part of the plan.

Occupational diseases present some unique features that must be considered in the development and application of standard case definitions for surveillance. Diagnosing an occupational disease often requires a physician to make an etiologic diagnosis using the occupational history, a consideration of nonoccupational risk factors for an illness, and a knowledge of known effects of occupational exposures. This process is difficult to translate into objective, simple criteria. Furthermore, labeling an individual as having an occupational disease may have profound implications. In some instances, the individual is at risk of losing his or her job. In other situations, a diagnosis may affect the involvement of the worker and physician with the workers' compensation system. Given the scientific, social, and economic issues related to occupational disease definition, it is essential that close attention be paid to the specific purpose of the standardized criteria being proposed.

Different criteria for the same disease may be used, depending on their intended use. For example, before the etiology of toxic shock syndrome was recognized, investigators developed a highly specific case definition using manifestations present in nearly all severe cases that had been seen.**[14] In this way, the investigators minimized misclassification errors in case-control studies that used cases found through surveillance. The use of this specific case definition for determining clinical case management, legal compensation, or disability would have been inappropriate, since it was never intended for any of those purposes. Similarly, NIOSH surveillance case definitions for occupational illnesses are intended for a specific application, i.e., the use of state health departments to facilitate standardized counting of cases and to help set priorities for follow-up of reported cases, and may differ from case definitions used in clinical medicine. Typically, since medical treatment may entail risk to the patient (and at times legal liability for the practitioner), practitioners tend to resist making diagnoses until a high degree of certainty is present. Such delay may act to the disservice of the patient and co-workers in cases in which the disorder may be accompanied by continued exposure to hazardous conditions. Thus, criteria applied to epidemiologic surveillance for prevention efforts may not be as "strict" (i.e., specific) as those used in clinical medicine or in epidemiologic studies of disease etiology. Likewise, our proposed epidemiologic case definitions may differ from criteria used to determine compensability (which depends on state laws) and disability.

Structure and Validity of Case Definitions

A case definition may include signs, symptoms, diagnostic tests, exposure history, and evaluation of possible nonoccupational causes of an illness. The relative importance of each of these components will, of course, vary among conditions. Because surveillance case definitions must be practical for use in a variety of states, they should not require the use of specialized diagnostic tests available only at referral centers.

Case definitions for surveillance should have at least moderate specificity and sensitivity. Ideally, the validity of case definitions would be assessed directly against appropriate "gold standards." Unfortunately, relatively few gold standards exist for occupational diseases, and those that do (e.g., lung tissue pathology) cannot be ethically applied to large numbers of living patients. Furthermore, the performance of case definitions in an actual surveillance system, as measured by their predictive value, will also depend on the prevalence of real occupational disease among reported suspect cases. NIOSH will, therefore, design case definitions that are generally consistent with the current clinical understanding of the conditions of interest, and that are practical for wide application by state health departments. NIOSH will also evaluate the performance of the case definitions and revise them as necessary, based on experience with their use in state surveillance programs.

The NIOSH surveillance case definition for work-related carpal tunnel syndrome is presented in Appendix I.

Application of Case Definitions in SENSOR Programs

The manner in which case definitions are used by state health departments will depend on the nature of the provider network, which may vary according to state and target condition. When the network of reporting providers is informal and not highly specialized, individual providers may encounter a given work-related condition infrequently. Case definitions should not be used to discourage such providers from reporting "non-cases." Providers instead should be encouraged to report any suspect cases of a target condition via a simple and convenient process. If additional data are needed to apply the case definition and determine the need for follow-up, they should be collected through follow-up contacts with the provider, patient, and, if appropriate, the employer. A similar process has been used for certain communicable diseases such as toxic shock syndrome and AIDS.[4] An example of the kinds of data that would be useful to describe cases and determine priority for follow-up of work-related carpal tunnel syndrome is provided in Appendix II.

This approach is designed to encourage reporting by otherwise reluctant providers. However, less specialized providers may lack knowledge needed to recognize possible cases of a target condition. To remedy this, we are recommending that states disseminate reporting guidelines to potential providers using state health department bulletins, state medical journals, and/or direct mail. These guidelines may be simplified and less specific versions of case definitions, intended to further clarify the provider's role in the surveillance effort and to aid in recognition of confirmed and suspect cases. By describing sentinel health events (occupational) (SHE[O]s) in clinical terms, reporting guidelines enhance the utility of the SHE(O) concept as a ". . . method for increasing physicians' awareness of occupational diseases. . . ."[15] Reporting guidelines may include text describing a given occupational disorder and explaining the procedure and rationale for reporting it. An example of reporting guidelines for work-related carpal tunnel syndrome is provided in Appendix III.

More formal networks may involve highly specialized providers that encounter a given target condition frequently. Such providers may be given detailed reporting forms or computer software for reporting case information. For con-

**Davies JP, personal communication, August 1986.

ditions with simple criteria, providers may be given the case definition to be used directly to identify reportable cases. For example, clinical laboratories may be asked to report all cases with blood lead levels exceeding a specified threshold.

Summary

Lists of reportable conditions and case definitions are important tools for epidemiologic surveillance. As part of an initiative to encourage occupational disease surveillance systems linked to intervention at the state level, we have proposed a list of target conditions and are developing a set of standard epidemiologic case definitions. Experience gained from state health department pilot projects using SENSOR and other surveillance approaches will be used to promote effective condition-specific surveillance strategies on a wider scale.

APPENDIX I

Surveillance Case Definition for State Health Departments: Work-Related Carpal Tunnel Syndrome

State health departments should encourage providers to report diagnosed or suspected cases of work-related carpal tunnel syndrome. The surveillance case definition can be used to classify reported cases. The surveillance case definition includes meeting criteria A, B, and C below. In certain settings, such as workplace surveys, a case definition consisting of criteria A and C may be useful.

A) Symptoms suggestive of carpal tunnel syndrome are present.

One or more of the following symptoms are sufficient: paresthesia, hypoesthesia, pain or numbness affecting at least part of the median nerve distribution of the hand(s). The median nerve distribution generally includes palmar side of thumb, index finger, middle finger, and radial half of ring finger; dorsal (back) side of same digits above PIP (proximal interphalangeal) joint; and radial half of palm. Pain and paresthesia may radiate proximally into the arm. Symptoms should have lasted at least one week or, if intermittent, have occurred on multiple occasions. Other causes of hand numbness or paresthesia, such as cervical radiculopathy, thoracic outlet syndrome, and pronator teres syndrome, should be excluded by appropriate clinical evaluation.

B) Objective findings consistent with carpal tunnel syndrome are present in the affected hand(s) and wrist(s):

EITHER

1) Physical examination findings.
   One or more of the following findings should be present: 1) Tinel's sign (paresthesia elicited or accentuated by gentle percussion over the carpal tunnel), 2) present or positive Phalen's test (paresthesias are elicited or accentuated by maximal passive flexion of the wrist for one minute), or 3) decreased or absent sensation to pin prick in the median nerve distribution of the hand.

OR

2) Electrodiagnostic findings of median nerve dysfunction across the carpal tunnel.
   Criteria for abnormal electrodiagnostic findings are generally determined by the individual laboratories.

C) Evidence of work-relatedness—a history of a job involving activities that increase the risk of carpal tunnel syndrome prior to the development of symptoms.

One or more of the following activities may be present:

- Frequent, repetitive use of the same or similar movements of the hand or wrist on the affected side(s).
- Regular tasks requiring the generation of high force by the hand on the affected side(s).
- Regular or sustained tasks requiring awkward hand positions, such as use of a pinch grip (as when holding a pencil), extreme flexion or extension of the wrist, or use of the fingers with the wrist flexed on the affected side(s).
- Regular use of vibrating hand tools.
- Frequent or prolonged pressure over the wrist or base of the palm on the affected side(s).

A temporal relationship of symptoms to work or an association with cases of carpal tunnel syndrome in co-workers performing similar tasks is also evidence of work-relatedness.

APPENDIX II

Recommended Core Surveillance Data for Reported Cases: Work-Related Carpal Tunnel Syndrome

The data items listed below should be collected on reported cases of work-related carpal tunnel syndrome in order to describe reported cases, set priorities for workplace investigations, and apply the surveillance case definition.

Demographic Information	
Name	Age
Home address	Sex
Phone number	Race
Provider Information	
Name	Specialty
Address	Type of Practice
Phone number	
Workplace Information	
Employer name	Department or work area of case
Address	Case occupation and most important activities or duties
Phone	
Type of business or industry	Number of employees with similar job duties as case
Number of employees	
Date case began current job	Number of other workers with similar symptoms as case
Clinical Information	
Date of symptom onset	Electrodiagnostic tests results (if performed)
Symptoms (quality, location, duration, number of episodes)	Job task factors described by case (repetitive hand motion, high hand force, awkward hand position, vibrating hand tool use, mechanical pressure over wrist or palm)
Physical findings (Tinel's sign, Phalen's test, objective sensory loss)	Temporal association between symptoms and work

APPENDIX III

Reporting Guidelines for Providers: Work-Related Carpal Tunnel Syndrome*

Definition and Clinical Features

Carpal tunnel syndrome is a constellation of symptoms and signs caused by compression of the median nerve as it passes through the carpal tunnel. In work-related carpal tunnel syndrome the cumulative effect of biomechanical stresses on the hands and wrist encountered in certain occupations has contributed to or has caused the condition. No reliable national data exist on the incidence of work-related carpal tunnel syndrome, but surveys of selected workplaces indicate that 5 percent or more of workers in some jobs may have carpal tunnel syndrome attributable to work.

Patients suffering from carpal tunnel syndrome usually complain initially of sensory symptoms, including pain, numbness, and tingling affecting part or all of the sensory distribution of the median nerve in the hand, often radiating proximally. Onset is usually gradual, but symptoms may be episodic, typically worsening at night or with strenuous activity involving the wrist and hand. Physical examination may reveal objective evidence of decreased sensation in

*State health departments may wish to adapt this material for dissemination to providers by including information on how to report a case and statutes or regulations, if any, governing disease reporting and confidentiality of case reports in their state.

the sensory distribution of the median nerve in the hand, a tingling sensation in the nerve distribution with percussion over the median nerve in the wrist (Tinel's sign), or pain or tingling sensations with sustained, passive wrist flexion (Phalen's test). However, physical examination may be normal in cases of carpal tunnel syndrome. Weakness of the muscles supplied by the median nerve in the hand, especially the abductor pollicis brevis, generally occurs after sensory symptoms have persisted for some time. Electrodiagnostic studies may show evidence of median nerve dysfunction with sensory and motor conduction velocity being slowed across the wrist.

Other conditions that may present like carpal tunnel syndrome include cervical nerve root compression, generalized peripheral neuropathy, thoracic syndrome, and the pronator syndrome (entrapment of the median nerve by the pronator teres muscle).

Jobs predisposing workers to carpal tunnel syndrome are common and include those requiring hand movements that are repetitive, forceful, or involve certain awkward hand positions. These positions include extreme flexion or extension and use of a pinch grip (used to hold a pen, as opposed to a power grip that is used to hold a hammer). In addition, the use of vibrating hand tools and direct external pressure over the carpal tunnel, as from a poorly fitting wrist band, are both occupational risk factors for developing carpal tunnel syndrome. Especially prone to developing carpal tunnel syndrome are workers whose jobs involve combinations of risk factors. Examples of high-risk jobs include garment workers, assemblers of electronic components, and painters.

Nonoccupational risk factors for developing carpal tunnel syndrome include rheumatoid arthritis, diabetes, hypothyroidism, gout, female gender, pregnancy, oral contraceptive use, and bilateral oophorectomy. However, the presence of one or more of these risk factors does not exclude the possibility that occupational factors have contributed to a case of carpal tunnel syndrome.

Recognition

Recognition of work-related cases of carpal tunnel syndrome is important because job redesign or reassignment may be beneficial to affected workers. Recognition of work-related carpal tunnel syndrome requires taking an occupational history as part of the evaluation of any patient presenting with symptoms suggestive of carpal tunnel syndrome. The occupational history should focus on assessing the patient's job for the presence of hand movements or other factors described above which might predispose to developing carpal tunnel syndrome. The patient should be asked about the timing of onset of symptoms in relation to any occupational risk factors identified and about similar symptoms in co-workers.

Reporting

Suspect cases of work-related carpal tunnel syndrome should be reported to public health officials, because a single case may be a sentinel for the presence of biomechanical stresses shared by a number of workers. Therefore, reporting cases to public health officials may provide the opportunity to prevent additional cases from occurring or progressing.

Physicians should report all suspected or diagnosed cases of work-related carpal tunnel syndrome. The reporting guidelines that follow are intended to assist providers recognizing such cases.

Cases meeting criteria A and B should be reported:

A) Symptoms or signs compatible with carpal tunnel syndrome are present.

B) The occupational history elicits one or more of the following:
   1) Job tasks involving repetitive or forceful movements or awkward postures of the affected hand(s) or wrist(s).
   2) Frequent use of vibrating hand tools with the affected hand(s).
   3) Frequent or prolonged pressure over the wrist(s) or base of the palm(s) on the affected side(s).
   4) Similar symptoms in co-workers performing similar job tasks as the patient.
   5) Symptoms are worsened on workdays or relieved on days away from work.

Suggested Bibliography

Armstrong TJ: An Ergonomics Guide to Carpal Tunnel Syndrome. Am Ind Hyg Assoc J, Ergonomics Guides, 1983.

Feldman RG, Goldman R, Keyserling WM: Peripheral nerve entrapment syndromes and ergonomic factors. Am J Ind Med 1983: 4:661–681.

Goodgold J, Eberstein A: Electrodiagnosis of Neuromuscular Diseases, 2nd Edition. Baltimore: Williams & Wilkins Co, 1977.

Sandzen SC: Carpal tunnel syndrome. Am Fam Physician 1981; 24:190–204.

Silverstein BA, Fine LJ, Armstrong TJ: Occupational factors and carpal tunnel syndrome. Am J Ind Med 1987; 11:343–358.

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REFERENCES

1. Millar JD, Myers ML: Occupational safety and health: progress toward the 1990 objectives for the nation. Public Health Rep 1983; 98:324–336.
2. Baker EL, Melius JM, Millar JD: Surveillance of occupational illness and injury in the United States: current perspectives and future directions. J Public Health Policy 1988; 9:198–221.
3. Konowitz DM, Petrossian GA, Rose DN: The underreporting of disease and physician's knowledge of reporting requirements. Public Health Rep 1984; 99:31–35.
4. Centers for Disease Control: Manual of Procedures for National Morbidity Reporting and Public Health Activities. Atlanta: Centers for Disease Control, 1985.
5. Department of Health and Human Services: Promoting health/preventing disease—objectives for the nation. Washington, DC: Govt Printing Office, 1980.
6. Centers for Disease Control: Leading work-related diseases and injuries—United States. MMWR 1983; 32:24–26, 32.
7. Langmuir AD: William Farr: founder of modern concepts of surveillance. Int J Epidemiol 1976; 5:13–18.
8. Langmuir AD: The surveillance of communicable diseases of national importance. N Engl J Med 1963; 268:182–192.
9. Sacks JJ: Utilization of case definitions and laboratory reporting in the surveillance of notifiable communicable diseases in the United States. Am J Public Health 1985; 75:1420–1422.
10. Centers for Disease Control: Guidelines for evaluating surveillance systems. MMWR 1988; 37(S-5):1–18.
11. Rose VE: Reliability and utilization of occupational disease data. NIOSH Pub. No. 77-189, 1977. Available from National Technical Information Service, Springfield, VA. No. PB-80-175-698/A08.
12. The Association of Schools of Public Health and the National Institute for Occupational Safety and Health: A Proposed National Strategy for the Prevention of Leading Work-related Diseases and Injuries, Part I. Cincinnati: National Institute for Occupational Safety and Health, 1986.
13. The Association of Schools of Public Health and the National Institute for Occupational Safety and Health: A Proposed National Strategy for the Prevention of Leading Work-related Diseases and Injuries, Part 2. Cincinnati: National Institute for Occupational Safety and Health, 1988.
14. Davies JP, Chesney PJ, Wand PJ, *et al:* Toxic shock syndrome: epidemiologic features, recurrence, risk factors, and prevention. N Engl J Med 1980; 303:1429–1432.
15. Rutstein DD, Mullan RJ, Frazier TM, *et. al:* Sentinel health events (occupational): a basis for physician recognition and public health surveillance. Am J Public Health 1983; 73:1054–1062.

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VI. Hazard Surveillance in Occupational Disease

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Introduction

Definition and Description of Overall Objectives

Hazard surveillance is the assessment of secular trends in exposure to toxic chemical agents in the workplace and to other hazards responsible for disease and injury. In a public health context, hazard surveillance identifies work processes or individual workers exposed to high levels of specific agents in particular industries and job categories. This enables timely intervention that will prevent occupational illness and its attendant morbidity and mortality.

As with disease surveillance, a hazard surveillance strategy is developed in three distinct steps: 1) data collection, including information on industry demographics, patterns of chemical use, and workplace exposures; 2) method development and data analysis; and 3) preventive action.

First, data collection on industry demographics should include the use of systematic industry codes, e.g., the Standard Industrial Classification (SIC), job categories, details on the industrial process, and related information on unionization, age of the facility, and the size of employment. Hazard information includes the identity and quantity of chemicals in use. Second, an analytic method must be created for evaluating the demographic, exposure, and toxicity information to meet surveillance objectives. For public health intervention, the hazard data should also include exposure as a function of job category or occupation. Finally, the outcomes of analysis should be tied to developing preventive actions that will limit exposure and thereby reduce the incidence of occupational disease and mortality.

When problems are identified, this information will enable development of intervention strategies that range from fine tuning of industrial hygiene controls to regulatory activity. The data will help characterize problems and assess the effectiveness and impact of overall prevention or regulatory strategies. Data on the extent of exposure to a given substance can also clarify the magnitude of the occupational disease burden associated with that substance. To predict future burdens from occupational disease would require data on dose-response relationships, disease endpoints, quality of the evidence, and the time-course of resulting illness and disease from exposure to a particular substance.

Intervention and prediction of the burden of occupational disease are two principal objectives of hazard surveillance. Exposure data must be considered when planning the use of resources, e.g., targeting inspections, planning such clinical services as emergency room capability, and developing targeted educational programs. Finally, in certain circumstances the data may provide information for epidemiologic studies that will evaluate dose-response relationships and suggest further research where the level of suspicion is insufficient to require intervention.

Benefits of Hazard Surveillance

Hazard surveillance is timely in identifying populations at risk of occupational diseases associated with continuous exposure (predominantly diseases with relatively long latency periods). Identifying workers at risk by assessing exposure may substantially reduce the burden of occupational disease through early intervention to reduce exposure. Surveillance techniques for chronic disease lack this primary-prevention aspect of hazard surveillance.

Where exposure data are as detailed as the job category level, hazard surveillance permits identifying exposures at the industrial-process level. This is important for identifying and evaluating control strategies. It also helps identify the number of employees per job category so that proportional sampling will allow determination of general exposure patterns and the burden of occupational disease. Identifying exposures by job categories can also help reduce misclassification in epidemiologic studies that rely on historical sampling data. Comparing hazard surveillance data across job categories in a particular environment enables the most problematic exposure areas to be identified and forms the basis for follow-up activity. Exposure data over time are widely significant for identifying both the continuing adequacy of control strategies and poorly controlled exposures across an industry or specific job category. Hazard surveillance complements the surveillance of occupational disease. The 1977 report* of a NIOSH task force on surveillance, chaired by Dr. Alexander Langmuir, concluded:

> "The surveillance of hazards and diseases cannot proceed in isolation from each other. The successful characterization of the hazards associated with different industries or occupations in conjunction with toxicologic/medical information relating

NOTE: Author affiliations and addresses are listed on p. 7.

*Craft B, Sundin G, Spirtas R, Behrens V: Draft report of a task force on occupational health surveillance. Cincinnati: National Institute for Occupational Safety and Health, 1977. (Unpublished) 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. Some agents are sufficiently effect-specific to make the task of illness surveillance relatively straightforward. There is a vast middle ground where exposures are complex and health effects diverse, that lends itself to resolution only through the combined efforts of cause-and-effect surveillance."

Existing Data Systems for Hazard Surveillance

National Occupational Hazard and Exposure Surveys

NIOSH pioneered the first approach to hazard surveillance in developing and applying the National Occupational Hazard Survey (NOHS) and the more recent National Occupational Exposure Survey (NOES).[1] These systematic surveys of industries resulted in exhaustive lists of substances and an estimated number of workers exposed. They are the only comprehensive attempts to date to estimate the nature and distribution of hazardous materials in industrial and commercial work environments. Cohort studies can have great value when NIOSH has identified substances that are used significantly in industry and for which there are toxicologic but limited human data. The survey data can also help direct epidemiologic investigations to the work locations most suitable for studying the health effects of particular substances.

The only industrial hygiene measurements of exposure in the two NIOSH surveys involved noise levels; chemicals identified in the surveys for each industry represented only potential exposures. NOHS recorded whether exposures were subject to engineering controls, whether personal protective equipment was required, and whether potential exposure of workers was full-time or part-time.

OSHA Integrated Management Information System

The second approach to hazard surveillance involves using computerized exposure information gathered in the Occupational Safety and Health Administration (OSHA) Integrated Management Information System (IMIS) during OSHA compliance investigations.†[2,3] This data set has the advantage of being the only computerized data available in the United States that include actual levels of exposure. To date, OSHA has used IMIS data only to establish inspection priorities.

Between 1972 and 1979, exposure measurements in broad categories for OSHA-regulated substances were recorded only as proportions of the permissible exposure limit. Since 1979, actual exposures have been included, as has the job title (uncoded) of the worker sampled.

The series of files in IMIS are linked by inspection number and contain information on the facility inspected, the inspection itself, test samples taken (both direct reading and laboratory samples), and any citations issued. Other information includes the name and address of the facility; the standard industrial classification (SIC); inspection type (e.g., general schedule, complaint, or follow-up); and demographic variables such as geographic region, total employment of the facility, number of workers affected by the inspection, and union status of the facility.

IMIS consists of various reports and records of federal OSHA inspections, but neither the Mine Safety and Health Administration (MSHA) nor most states with OSHA programs of their own contribute data to this system. Although "state plan" states must provide such data to meet the requirement that they be "at least as effective as" federal OSHA, the pace of compliance has been slow. Thus, surveillance of silica exposures in the stone quarrying and cutting industry, located predominantly in Vermont and North Carolina, cannot be accomplished using IMIS. Also, silica exposures in foundries cannot be accurately estimated because such states as Michigan, with a large workforce employed in foundries, are not part of IMIS. At some time in the future, all states are expected to contribute to IMIS.

Coal Mine Sampling Data from MSHA

The Mine Safety and Health Administration supervises a sampling program[4a,4b] that is, in certain respects, ideal for hazard surveillance. The MSHA exposure assessment program covers virtually all underground and surface coal miners who are exposed regularly or intermittently to coal dust. The frequency for exposure monitoring depends on the potential exposure level, but it is usually more often than quarterly. Individual companies collect the samples using approved sampling techniques and send them to an MSHA center for measurement and recording. Because all samples are reported continuously to the regulatory agency, these data can be used for hazard surveillance in their present form. Currently, approximately 200,000 coal miners employed in approximately 12 large coal mine companies and a large number of smaller mines are covered by this sampling program.

Limitations of Existing Data Collection

Only two databases with potential value for hazard surveillance are currently available in the United States. The limitations of other information sources for chemical use and exposure are described in the report to the Department of Health Services, State of California mentioned earlier in this paper.† The discussion here will focus only on the NIOSH NOES/NOHS and the OSHA IMIS.

NIOSH NOES/NOHS Data

NOHS and NOES identify only potential chemical exposures in work settings. Although these systems can identify the use of a given material, they cannot provide information to determine whether that particular use is within a standard or other pertinent exposure level. Changes in levels cannot be explored on a regular basis, although a comparison of NOHS and NOES may give some indication of change. Estimates of the number of workers associated with use of a substance are possible, but information on only the presence and not the effectiveness of environmental or personal protective equipment is available.

Although these problems were recognized when the surveys were developed, they were offset by the value of these surveys for other uses. These are the most comprehensive systems available that identify where possible exposures may occur, but they cannot be used to characterize exposures for projecting the risk or the potential burden of occupational disease.

†Froines JR, Dellenbaugh CA, Seabrook SS, Wegman DH: A profile of occupational health experience in Los Angeles County, 1984. Los Angeles Southern Occupational Health Center, University of California. (Unpublished report to the Department of Health Services, State of California)

Despite these substantial limitations, the large number of substances identified in NOHS and NOES offer a substantial advantage. This advantage is realized through the use of data in the NIOSH Registry of Toxic Effects of Chemical Substances (RTECS), which covers approximately one-third of the substances found in NOHS and NOES. The other two-thirds not included in RTECS are such things as physical agents, biologic agents, and chronic trauma hazards. An important problem about the scope of data available in RTECS should, however, be recognized. RTECS includes substances believed to be of toxicologic importance to humans, and this involves approximately 80,000 substances. Most of these substances are included, however, because of data derived from examining only acute toxicity. Relatively few substances have been subjected to chronic studies because such studies are expensive and are limited primarily to suspected carcinogens. The agents for which substantial human toxicity data are available are almost all included in the 400 substances regulated by OSHA. They are, therefore, in the IMIS system.

OSHA IMIS Data

Several problems exist with the use of the OSHA IMIS for surveillance. These include:

- The number of chemicals included is limited to only those substances regulated by OSHA (approximately 400). This limitation may not be as important as it first appears, however, because these materials are generally recognized as reasonably widespread in industrial use and as the most hazardous to human health. American Conference of Governmental Industrial Hygienists Threshold Limit Values have been established for all of them. A more important limitation is the unequal attention given to the 400 substances. Indeed, after 15 years of industrial hygiene compliance sampling, 75 percent of the data in the current system relate to only 15 substances.
- There is a limit on the industries investigated. The small staff historically assigned to the OSHA compliance activity has significantly limited the number of workplaces that could be investigated. Thus, only a relatively small proportion of most industries is represented in the database.
- Some states fail to report to IMIS.
- There is a lack of systematic entering into IMIS of *all* data collected in compliance inspections.
- The failure to collect job-title information according to a common system is a serious limitation.
- An uncertainty exists of whether the inspection process, or even the method of selecting industries for inspection, results in data that are reasonably representative. OSHA seeks to assess the compliance with existing standards rather than to determine the overall distribution of exposure to given chemicals in industry. Although IMIS represents the only exposure data available, any possible bias must be evaluated before the value of these data for estimating the overall distribution of exposures can be determined. This, too, may not be as important for surveillance as it seems because identifying and tracking worst case situations focuses attention on problem areas. It does, however, affect the use of these data for estimating the nationwide magnitude of problems with a particular substance.

The OSHA inspection process should be examined before reviewing the use of IMIS data for hazard surveillance. Four criteria are used to select industries for inspection: general inspection schedule, complaints, accident investigations, and follow-ups—the latter two being very small in number. In the past, general schedule inspections have been derived from an algorithm that identifies high priority SICs on the basis of the number and severity of health hazards and employment size. A random-number generator is used within high-hazard SICs to determine the actual inspection order. This limits any inappropriate periodicity in the general schedule over time.

The second and largest category involves inspections in response to complaints. Theoretically, complaints would relate to specific identifiable problems, and violations would reflect the specific problem named in the complaint. Jones and co-workers†† have suggested, however, that complaints may not direct inspectors to the most important exposures. Compliance officers may address only the specific complaint named in an inspection and thereby miss or undersample other important exposures.

The sampling process itself may be a source of bias in IMIS data. OSHA requires that representative jobs be selected and that sampling be conducted for employees having the highest exposures. The knowledge that an inspector is monitoring exposure may, however, affect work practices, the use of ventilation, and other factors that could minimize measured exposures. It is difficult, therefore, to predict whether a set of exposure measurements will over- or underpredict actual exposures. Finally, Jones and co-workers have pointed out that although inspectors are required to report all compliance samples in IMIS, some fail to do so. This could result in an upward bias if the samples not systematically reported showed little or no exposure.

Jones and co-workers have reviewed these issues in some detail. They conclude that the issue of whether a bias exists is ambiguous. Although their empirical results suggest that a reporting bias is not a major problem, they do consider it plausible that some bias occurs in the sampling process. Unfortunately, no test is available using existing data to assess the direction or magnitude of such a bias. It may, in fact, be extremely difficult for industrial hygienists to predict which individuals have the highest exposures (Dr. R. Spear, personal communication). Given such factors as behavior alterations during inspections and the extreme variability among compliance officers in their approach to sampling, it is reasonable to assume that some bias may be present in exposure measurements. However, the magnitude of such a bias has not been measured, and its direction may vary. Additional studies are clearly needed in this area. In the meantime, our own analysis has led us to conclude that IMIS is useful for surveillance.

Both databases described here (NOHS/NOES and IMIS) have potential value despite their acknowledged limitations. Additional research is needed to evaluate further their efficacy for surveillance.

Hazard Surveillance Models

Before discussing alternative hazard surveillance systems, we should briefly discuss other existing data sources

††Jones CA, Weld L, Gary W, Greenlee P, Wiarda E, Chul HJ: Methods for analyzing compliance with OSHA health standards, with application to the asbestos case. Final report 1986 (NIOSH grant no. IR030H02135-01).

that may be useful in hazard surveillance and ways to improve the systems discussed above. A central requirement for developing hazard surveillance models is to determine where information on chemical use and exposure can be obtained.

Chemical Use

Four potential databases are available that might help identify chemical use. The information they provide may, in fact, overlap. The first two have been discussed at length, NOES/NOHS and IMIS. The other two result from the Emergency Planning and Community Right to Know Act of 1986 (within the jurisdiction of the Environmental Protection Agency) and the Hazard Communication Standard (within the jurisdiction of OSHA). The Right to Know Act, passed as part of the Superfund reauthorization, is a potentially rich source that could be explored for data on chemical use, but initially its organization, structure, and accessibility may be a problem. The OSHA Hazard Communications standard requires that employers maintain material safety data sheets for certain chemicals found in particular establishments. The chemicals for which these data sheets are required are listed in references to the standard. Data generated from this standard could constitute an ongoing survey.

Chemical Exposure

IMIS—To maximize the effective use of the IMIS database for surveillance, some of the problems noted above must be addressed. The scope of coverage for the industries inspected should be expanded, and greater attention should be given to the material safety lists employers are required to maintain so that the maximum number of substances to be sampled can be defined. State data should be included in their entirety, and data entries should be complete.

The most difficult problem is the philosophical difference between the goal of OSHA (i.e., determining compliance with standards) and that of surveillance (i.e., assessing the actual distribution of exposures in a workplace). We believe that any bias is limited and that the data are useful for surveillance. Additional sources of information are required that use approaches explicitly designed for surveillance. Meanwhile, it is appropriate that NIOSH and OSHA establish a joint taskforce to determine how the industrial hygiene field manual could be modified to provide greater direction for compliance officers in designing sampling strategies that maximize the potential for assessing variance in the data and for assuring completeness of the gathered data. A systematic approach is also required for collecting job category information.

NIOSH Health Hazard Evaluations

NIOSH industrial hygienists collect a substantial number of samples in many Health Hazard Evaluations (HHEs). Although NIOSH conducts far fewer HHEs than OSHA compliance inspections, the data have both more depth and more within-the-plant breadth. Thus far, this valuable resource has not been used effectively. Results of the HHEs should be organized into an accessible database, and the data should be integrated with information collected by OSHA and stored in IMIS.

The sampling strategy designed for an HHE is fairly similar to that employed by OSHA to define a problem; however, the data collected may not be representative of what would be obtained from a random sample design. It is unlikely that NIOSH could accommodate surveillance needs in the context of conducting HHEs, but small modifications of the sampling protocol and subsequent reporting may facilitate using the data beyond the scope of specific HHEs. Candidates for modification might include information on the number of employees, how many are in specific job categories, the job categories themselves, other exposures, and an estimate of the representativeness of collected data. Information for some of these is already collected, but further consideration should be given to how this rich source of information can be expanded.

Alternative Hazard Surveillance Systems

Environmental Monitoring through the Existing 6(b) Process for Standards

Within the existing framework of work environment standards, a means exists to develop hazard data sufficient for a variety of surveillance needs. Such a system could exploit those sections of the standards that call for environmental monitoring of regulated substances. Currently, this would apply to those materials for which permissible exposure limits (PELs) have been set through the OSHA 6(b) rulemaking process. These substances include acrylonitrile, asbestos, arsenic, benzene, coke oven emissions, cotton dust, ethylene oxide, formaldehyde, lead, and vinyl chloride. These requirements are based primarily on routine monitoring of exposures that exceed a given action level (usually 50 percent of PEL). Currently, no report of this sampling is mandated; the company need only maintain records so that a compliance officer can review them during a compliance visit. If such monitoring data were collected and reported to OSHA in a reliable, systematic, and routine fashion, they could form the basis of an important segment of a hazard surveillance system.

The level of information necessary and sufficient for surveillance can be determined by examining what might be achieved if complete information were available on any given substance. The health risk for most 6(b) substances is usually cancer (only lead and cotton dust are exceptions), and the relevant exposures are usually of the long-term, cumulative type.

Exposure to benzene is a typical example. An ideal data set on benzene would provide specific exposure data for each exposed worker according to that individual's job within the plant and where that job occurred. The information would be specific for each industry that uses benzene within each state or region. If such information were recorded and accessible, it would be possible to determine how many persons were subjected to any level or range of benzene exposure, with the information specific to geographic areas, industries, plants, jobs, and individuals. Problems could be located by geographic region, plant size, type of use, duration of use, etc., all based on characteristics associated with individually recorded exposure measurements.

Although such an ideal set of information is unobtainable, exposure information could be collected on a sample of facilities so that exposure patterns by job category for specific industries could be estimated on a regional or national basis. Reports of workplace exposures could currently be required, for example, from a sample of companies that carry out environmental monitoring to comply with 6(b) standards. Whether surveillance results were used to target prevention efforts or to estimate the burden of occupational disease, some level of detail on job category would be necessary. Other important variables include plant size, the degree of unionization, and plant age (for example, annual capital investment or annual maintenance dollars in relation to the size of the workforce). Such a surveillance scheme is most appropriate for exposures associated with chronic health conditions in which an eight-hour time-weighted average is likely to be the most pertinent environmental measure. Whether it would be appropriate for exposures that cause acute symptoms or disease with short latency in which exposures may involve short-term peaks is yet to be determined.

Unfortunately surveillance was not a goal when OSHA designed environmental monitoring requirements for the 6(b) standards promulgated since 1974. Again benzene is a good example. The benzene standard requires an employer to conduct initial monitoring for benzene exposure. No additional monitoring is required if the initial determination is below the action level, but subsequent exposure monitoring is required if the initial measure is above the action level or the PEL. (The frequency of subsequent monitoring depends on the actual level.) Data from such subsequent monitoring could be used for surveillance if results were weighted to account for differences in sampling frequency and adjusted to account for the population of workers exposed below the action level who will not be sampled periodically.

The use of environmental monitoring data as presently constituted also poses an uncertainty as to what proportion of a work population the measured levels actually represent. In addition, no provision in any of the standards requires an employer to develop a sampling plan that describes the basis of the monitoring strategy. Finally, because environmental monitoring focuses on identifying excessive exposure, a potential lack of representativeness exists.

These problems are not insurmountable, and existing standards could be modified to improve the effective use of these data for surveillance. The generic standard described below relies on a self-conscious design that provides a basis for assessing exposure rather than compliance.

Developing A Generic Approach

Any surveillance system based on standards is currently limited to substances with specific requirements for environmental sampling. PELs adopted from the 1968 American Conference of Governmental Industrial Hygienists Threshold Limit Value (ACGIH TLV) list are not accompanied by any environmental monitoring requirements. Considerable attention has focused on the importance of a standards-completion project that adds requirements (e.g., environmental and biologic monitoring, medical surveillance, respiratory protection, and training) to broaden the scope of consensus standards without conducting individual rulemaking for each substance. If environmental monitoring requirements could be established through a generic monitoring rule, hazard surveillance would be possible for almost 400 chemical substances. Such a generic rule would be of great value in itself, and the additional function it would have for hazard surveillance and for estimating the burden of substance-specific related disease should stimulate serious consideration for its promulgation.

To develop a generic standard, it is necessary to recognize the twofold objectives: compliance and surveillance. To serve both objectives, the organization and frequency of sampling must be considered along with any special requirements of surveillance that go beyond those of compliance. We can reconcile the needs of both objectives in the following proposal.

We propose that environmental monitoring be subdivided into two components: 1) existing environmental monitoring that requires initial monitoring, followed by periodic monitoring when the action level or PEL has been exceeded; and 2) additional environmental monitoring that would be required regularly but less frequently for surveillance. To characterize the full distribution of exposures, these comprehensive surveys would be conducted based on national random samples without regard to the action level.

Compliance

Standards that currently require environmental monitoring for compliance do not specify a formal sampling program nor do they take advantage of a job-category concept. The terms "category" or "exposure zone" derive from the work of Corn and Esman who defined exposure zone as follows: "Employees in a facility are apportioned to exposure zones based on process, work tasks, and contaminant source and removal similarities in such a manner that when a sufficient number of employees are sampled in each zone, the information obtained describes the exposure levels for all employees within a predetermined interval variation and statistical confidence."[5] The term "job group" used throughout their paper refers to the above approach. A compliance objective could be met more satisfactorily if a more rational sampling scheme were specified. The current practice for environmental monitoring relies on professional judgment to identify areas or jobs that may require intensive sampling. It is proposed that judgment be exercised primarily in classifying jobs into categories (exposure zones). When the categories are established and the number of workers per zone identified, a strategy of representative, random sampling weighted toward highly exposed workers in each zone could be carried out. Thus, the first step in developing a generic standard requires that employers review their industrial processes, establish exposure zones, and develop representative sampling strategies.

Regular environmental monitoring could then be conducted according to this plan as required by the standard. Initial comprehensive monitoring would be followed by monitoring at designated frequencies where the action level is exceeded.

Surveillance

A generic standard will also meet surveillance objectives if a representative survey of exposure is conducted periodically in a randomly selected sample of facilities. The number of plants to be surveyed for any given material will depend on the level of detail for which projections are desired.

The sample will necessarily require fewer large plants than small ones, but the plants to be included will be determined by a scheme modeled on one the Bureau of Labor Statistics used to secure estimates of injury and fatality rates. The sampling scheme will likely be based on information about the number of workers per job category per plant size per industry type per state and also on data from NOES for the number of employees "exposed" to each chemical substance.

The sampling unit would be an individual plant. Once selected into the sample, each plant would supply all environmental data collected according to requirements of the specific standard, including defined job categories. The number of plants selected will depend on a) the level of detail desired (national, state, industry type, plant size, etc.); b) size of plant; and c) the number of plants that fall into each size category (e.g. <10, 10–49, 50–249, 250–500, >500 employees).

Data collected through this sampling network would be summarized to provide information on the magnitude of the problem, a means of comparing progress over time, and a means of comparing excesses in exposure for individual substances. Thus, the distribution of exposures could be evaluated for each substance under surveillance, and trends in improvement or deterioration of control could be monitored for each. An evaluation of how each substance compares with other hazardous materials would allow the establishment of relative priorities for intervention.

The hypothetical distribution for four substances is presented in Table 1 as an example of results that might be developed from such a a scheme. Based on these data, 90 percent of the workers exposed to benzene have exposures below the PEL, 75 percent of those exposed to lead are below the PEL, and only 50 percent of those exposed to cotton dust are below. Asbestos exposure, by contrast, has been well controlled, and in this hypothetical case, all but 10 percent of the workers are exposed to less than 15 percent of the PEL.

An obvious concern with data generated this way is the possibility that monitoring will not be conducted appropriately and that test samples will not be evaluated with adequate quality control. To help address these concerns, sampling programs should be evaluated during routine compliance inspections and assistance should be provided at that time to correct inadequacies. To spot check the effectiveness of each program, compliance officers might also collect samples during their routine visits to parallel samples collected in the facility's own program. To ensure adequate quality control, it is proposed that all environmental samples be sent to laboratories that have been certified (for example, by the American Industrial Hygienists Association) and that sample results be copied and sent to OSHA.

TABLE 1—Regulated Substances according to Percent of the PEL (hypothetical data)

Percent of Exposed Workers	Percent of PEL: Benzene (50t)*	Asbestos (2000t)*	Cotton (125t)*	Lead (280t)*
10	10	1	10	5
25	20	5	50	20
50	50	8	100	80
75	80	12	200	100
90	100	15	300	120
100	150	150	600	300

*Estimated number of workers (in thousands) exposed nationally
PEL = Permissible Exposure limits.

Summary and Conclusion

We have reviewed existing data sources available for conducting hazard surveillance. Both the NIOSH NOHS/NOES and the OSHA IMIS can have significant value for hazard surveillance that is designed both to establish priorities for various preventive strategies—including intervention, research, and planning—and to complement disease surveillance. These systems also have certain limitations that affect their overall value in these regards.

We have proposed alternative hazard surveillance systems that would expand the database on actual exposures in the workplace by requiring that industry systematically conduct environmental monitoring for defined substances and then provide the data to OSHA and NIOSH for use in hazard surveillance.

REFERENCES

1. National Institute for Occupational Safety and Health: National occupational hazard survey. Pub. No. 78-114. Cincinnati, OH: National Institute for Occupational Safety and Health. Order from National Technical Information Service, Springfield, Virginia. No. PB-82-229-881-A99.
2. Froines JR: Hazard surveillance. *In:* Proceedings of the symposium of occupational illness statistics, 1986. Available from the Bureau of Labor Statistics, US Department of Labor, Washington, D.C.
3. Froines JR, Wegman DH, Dellenbaugh CA: An approach to the characterization of silica exposure in US industry. Am J Ind Med 1986; 10:345–361.
4a. Title 30, Code of Federal Regulations, SECTION 71. Mandatory health standards—Underground coal mines. Part 70.100–70.220: Dust Standards.
4b. Title 30, Code of Federal Regulations, SECTION 71. Mandatory health standards— Surface coal mines and surface work areas of underground coal mines. Part 71.100–71.220: Respirable Dust Standards.·
5. Corn M, Esman NA: Workplace exposure zones for classification of employee exposures to physical and chemical agents. Am Ind Hyg Assoc J 1979; 40:47–57.

VII. Hazard Surveillance at NIOSH

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Introduction

The goal of hazard surveillance is to develop information that contributes to the prevention of occupational disease and death. Effective primary prevention can perhaps most logically be achieved by early detection of an agent's potential for harm, identification of the occupational groups exposed to the agent, and dissemination of this information to those who are in a position to interrupt the disease process. "Primary prevention connotes the exclusion, cessation, or limitation of exposure so that the disease process is not initiated."[1] Because surveillance of hazards does not rely on detecting patterns of excess disease or death, it is—at least in theory—a particularly promising technique for identifying targets for intervention before the disease process has begun.

It would be unreasonable to expect universal agreement on the question of what sort of information should be developed by a hazard surveillance program. Indeed, the answer depends substantially on the ultimate usage envisioned for the information. One possible strategy for hazard surveillance might focus on locating and monitoring groups of workers who are exposed to agents with well-known adverse health effects. This would permit keeping exposure levels low enough to prevent illnesses from developing. A second and distinctly different strategy for hazard surveillance might focus on discovering previously unrecognized relationships between exposure and disease. This can be done by constructing comprehensive inventories of potential exposure agents found to be associated with occupational groups and using these data in conjunction with sources of toxicologic or epidemiologic information. Hazard surveillance programs designed to monitor a few well-understood hazards are frequently found in the context of programs designed to assess compliance with existing exposure standards (e.g., OSHA environmental monitoring to identify violations of the lead standard). Hazard surveillance efforts designed to discover new agent-disease links are more likely to be elements of research programs that identify exposure agents or occupational groups for epidemiologic studies to provide a base for developing future standards or regulations. Perhaps not unexpectedly, the hazard surveillance program at NIOSH, which this paper describes, has evolved along the lines of the latter (discovery) strategy.[2]

The adequacy of such a hazard surveillance program can be judged by how successfully it answers certain basic questions:

- What exposure agents are found in the workplace?
- What is being done to control these exposures?
- Which agents affect the most workers?
- Where are exposed workers found?
- What health effects might these exposures produce?
- How are occupational exposures changing over time?

Even in a world bounded by practical realities, defining and aspiring to an ideal is often useful. Although such an optimum goal may, in fact, be unattainable, the task of designing strategies to approach it and the process of measuring success is simplified when a clear picture of the "perfect world" is available. In forming a concept of the ideal system for surveillance of occupational health hazards, we might envision having current and continuous information available for analysis on the exposure levels of all chemical, physical, and biologic agents for all working men and women in the United States. For each of these agents, we would also have detailed information on human dose-response relationships and the interactive effects of multiple exposures. For those situations where engineering controls or personal protective devices were in use, we would know the degree to which exposures were being attenuated by those controls or devices. Ideally, our capability for analyzing this mountain of data would be limitless, and our ability to disseminate intelligence would be unfettered.

Unfortunately, substantial real-world obstacles usually prevent the achievement of this optimum state. The array of chemical, physical, and biologic agents in the nation's five million workplaces is staggering, and the mix is constantly shifting as new agents are discovered and new processes are introduced. Even identifying a particular exposure agent can be a formidable task because component information on exposure agents that occur as formulated products is often obscured by trade names, common names, or ambiguous terms. Most hazard surveillance systems use the Standard Industrial Classification (SIC) coding scheme to classify facilities into industrial groups. The SIC coding system, however, was not designed to classify industries on the basis of common exposures. Consequently, a high degree of variability may exist among facilities that share an SIC code, and this may impair the inferential value of data collected from a small number of establishments.

Additional problems await persons who wish to obtain hazard surveillance information that includes environmental sampling data. Sampling and analytic methods exist for only approximately 500–600 agents,[3–10] but most studies suggest that more than 10,000 different potential exposure agents are present in the occupational environment. Costs of collecting

NOTE: Author affiliations and addresses are listed on p. 7.

and analyzing environmental samples vary widely, depending on the agent and sampling strategy, but probably average at least $50 per analyte. Human dose-response data exist for only a handful of exposure agents, and toxicologic information from animal studies is lacking for most chemical agents found in the workplace.[11]

The difficulties associated with hazard surveillance and the deficiencies of existing data systems should not, however, deter efforts to pursue a vigorous program. When surveillance systems for cause (hazard) and effect (disease) are integrated and linked, the potential for discovery is enormous. For some hazards (e.g., asbestos), the disease outcome is well-defined; in these cases, the role of hazard surveillance is to locate occupational groups exposed to the known disease-causing agents so that controls or other intervention measures can be implemented. However, the vast majority of workplaces present a complex picture of mixed exposure agents, diverse symptoms, and incomplete data. In such real-world situations, the combined efforts of hazard and disease surveillance are required to solve the puzzle. Thus, surveillance of hazards and of diseases cannot realistically proceed in isolation from each other, at least for research purposes.

History

The history of efforts at NIOSH for hazard surveillance is outlined here to provide a summary of major project initiatives that took place during the years following passage of the Occupational Safety and Health Act of 1970. We will not attempt to describe or evaluate the activities or strategies of other federal agencies, states, or the private sector in carrying out hazard surveillance.

1970–1975:

The Occupational Safety and Health Act of 1970 (PL 91–596) gave NIOSH several broad mandates. The first director of NIOSH created seven implementation task forces to assist him in meeting these new mandates. The task forces consisted of members drawn from the public and private sectors to study selected aspects of the NIOSH mission and to recommend strategies for responding to legislative directives. The Task Force on Hazard and Disease Monitoring filed its report on February 16, 1971, and recommended that NIOSH undertake a National Occupational Hazard Survey to determine the extent of exposure to occupational hazards and the degree to which such exposures were being controlled. The results of such a survey would aid in setting up priorities for the NIOSH research agents. Such a survey would also replace the National Surveillance Network (NSN) that was in place at the time the OSH Act was passed. The NSN consisted of cooperative agreements with state occupational health agencies under which results of the states' workplace inspections would be shared with NIOSH. In turn, NIOSH would automate and analyze the data and supply annual reports back to the cooperating states. No more than 10 states participated in the NSN at any time, and deficiencies existed in the scope of coverage and the standardization of techniques for data collection.

The National Occupational Hazard Survey (NOHS) was initiated in February 1972 with a team of 20 field surveyors. Over the next two and one-half years, data were collected in a sample of 4,636 establishments that employed nearly 900,000 workers in 67 different metropolitan areas. Facilities were selected for the survey to include all industries covered by the OSH Act, and the sampling scheme was specifically designed to permit development of national estimates from sample results. Information was collected for each establishment surveyed on the type and extent of industrial hygiene and safety engineer services, medical and health care provisions, status of health records and physical examinations of employees, policies for personal protective equipment, type of workers' compensation insurance, and injuries and illnesses reported on OSHA Form 102. A complete tour of each establishment was then undertaken, during which the surveyor recorded job titles for all employees and listed all potential exposure agents, including trade-named products. The duration of each potential exposure was classified as full- or part-time, and the types of personal protective equipment or engineering controls in use were recorded. NOHS eventually resulted in a list of nearly 9,000 different potential exposure agents. Approximately 86,000 different trade-named products were identified as potential exposures. This necessitated a large-scale data-gathering activity following the field phase of the NOHS to obtain detailed component information from the manufacturers of the trade-named products. Satisfactory component information was eventually compiled for approximately 72,000 products.[12–16]

1975–1980:

The NOHS database found immediate and widespread applications in many phases of NIOSH and other federal research. A major purpose of NOHS was to provide, for the first time in this country, answers to the questions listed in the Introduction of this paper. Before NOHS data were available, no national database existed for estimating the number of workers potentially exposed to chemical, physical, or biologic agents. Similarly, the extent of control technology being used was known only for a nonrepresentative sample of workplaces. NOHS data also found extensive use as one input for determining priorities for OSHA inspections. It was referenced in NIOSH criteria documents and consulted as a source of information on chemical ingredients for over 70,000 trade-named products found in US worksites.

One notable application was the use of NOHS data in combination with data from the NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) to produce a model capable of systematically identifying high-risk employee groups.[3–10] Because NOHS does not provide direct information on health effects of the 9,000 potential exposure agents, it was logical to link the file to RTECS, which provides extensive information on the results of toxicologic studies on many agents. By using RTECS data to create severity indices for NOHS agents, it was possible to construct overall severity indices for particular occupations or industries, based on potential exposure agents associated with that group. The output from such a linking and modeling process is a list of industries or occupations, rank-ordered on the basis of potential health risk. The model is designed to permit liberal production of custom outputs based on criteria supplied by the user. It is possible, for example, to focus the model on only chronic health effects, or to combine all effects in a weighting scheme chosen by the user. The outputs from such a model have obvious value for those who wish to identify groups of workers with elevated potential for health risk from occupational factors or to explain increases in disease outcomes among occupational groups.

Although the RTECS file contains data on an impressive array of agents, fewer than 2,000 of the 9,000 potential exposure agents recorded during NOHS were listed in RTECS. In an effort to expand the coverage of the NOHS-

RTECS model, NIOSH supported research into a system designed to apply structure-activity principals to the NOHS compounds not listed in RTECS. As a result of this effort, NIOSH obtained a predictive toxicology system that is capable of generating estimates of potential toxicity for four different endpoints (acute toxicity, carcinogenicity, teratogenicity, and mutagenicity) for chemical agents that can be described structurally and that meet certain other eligibility requirements.[17] Other applications of the system as a hazard surveillance tool, in addition to its role in improving the NOHS-RTECS model, include providing estimates of an agent's potential toxicity even before animal testing has been completed.

The NOHS file was also used during this period to depict the presumed geographic location of occupational groups potentially exposed to selected agents. By linking the NOHS file to a national industrial demographic file, it was possible to produce computer-generated maps of the nation or selected states or regions which would graphically portray county-specific potential exposure patterns. The output characteristics of these maps could be adjusted to show the geographic spread of establishments or employees, or population-based rates by county for potentially exposed groups. These heuristic techniques were intended for possible applications in generating or testing hypotheses.[18–20]

Two other approaches for obtaining hazard surveillance data were explored during this period. First, contacts were made with many major national and international unions to help establish a collaborative relationship under which the unions would compile detailed lists of agents to which their members were potentially exposed and forward this information to NIOSH. NIOSH would then search the nonproprietary portion of its files on product-ingredient information to identify ingredients of any items on the list that were trade-named products. Then NIOSH would supply information on the possible toxic properties of agents for which such information was available. Presumably, the unions would then be better able to bargain for improved health and safety programs for their membership. Although this program is still in existence, the number of participating unions has declined.

The second strategy targeted employers as sources of hazard surveillance data. Through the Cooperative Exposure Survey (CES), employers applied the observational survey techniques used in NOHS to inventory the potential exposure agents in their own establishments.[21] A self-survey kit was assembled, including forms and instructions necessary to conduct an establishment survey. When NIOSH received the completed forms, it would review the list for any trade-named products for which ingredient information was available. In addition, NIOSH would identify agents for which exposure standards existed or for which toxicologic information could be obtained and send such information back to the employer with any other NIOSH publications that contained appropriate subject matter. Both of these data-gathering strategies had obvious and known deficiencies, especially regarding the production of representative, reliable data. They were conceived as alternative surveillance techniques, designed to be more fully explored as components of a hazard surveillance program if NIOSH could not conduct field-based national surveys like NOHS.

Early in 1976, the Director of NIOSH requested formation of a NIOSH Task Force on Occupational Health Surveillance to address the problem of establishing a viable surveillance program for the Institute. An eight-member group composed of recognized experts in occupational health and surveillance met several times over a period of four months and, in August 1977, produced a report (unpublished) for the Director. Although much of this "Report of a Task Force on Occupational Surveillance" dealt with strategies for disease surveillance, a key recommendation was that NIOSH conduct a second national hazard survey modeled after NOHS. The Task Force reasoned that NOHS provided valuable inputs to the NIOSH research mission, and because the data were aging, an update was necessary. Accordingly, plans for a second national survey were initiated.

1980–Present:

On November 1, 1980, the field phase of the National Occupational Exposure Survey (NOES) was initiated.[22] A total of 4,490 establishments employing 1.8 million workers were surveyed during the field phase, which ended in May 1983.[23] The survey was conducted in 98 different metropolitan areas and covered all types of industry except mining; certain agricultural sectors; federal, state, and local governments; financial institutions; wholesale and retail trade; and certain professions. NOES was patterned very closely after NOHS, although improvements were made in the data automation procedures. Questions were added on gender of potentially exposed employees, and selected chronic trauma events were added as recordable potential exposure agents. As in NOHS, approximately 70 percent of all potential exposure agents were recorded in the form of trade-named products. More than 100,000 different trade-named products were recorded, and efforts continued to obtain component information. The data from NOES are provisional until such time as a satisfactory proportion of the trade-named products are resolved.

As of June 1988, approximately 50 percent of the trade-named products had been resolved. More than 10,000 different potential exposure agents have been identified, and this total will expand as resolution of trade-named products continues. Because NOHS and NOES both collected data in much the same way, analysis of temporal changes between the two surveys will be possible. Approximately 30 questions asked during the interview phase of each survey are similar enough to support this type of trend analysis, and certain of these analyses, which do not require complete product ingredient information, have begun.[24]

NIOSH reformatted the NOHS file as a job-exposure matrix (JEM) to facilitate its use in epidemiologic applications.* Data from establishments in the same industry were combined to create a three-level hierarchical file. Each level of classification is nested within the previous one, beginning at the industry level. Thus, the three levels of classification of JEM are industry, occupation within industry, and potential exposure agent within occupation within industry.

Two major epidemiologic applications are expected. The first application is to increase the specificity of potential exposures. Many case-control studies rely solely on the industry and occupation descriptors found in records that were not designed for research purposes, e.g., death certificates. It appears from the work of Sieber* that by using JEM, cases (and controls) can be subdivided further to identify those occupational groups within an industry where potential exists for exposure to a hazard of interest.

*Sieber WK: Use of a job exposure matrix in epidemiologic analyses. Submitted manuscript.

The second application is to use JEM to expand the utility of the list of Sentinel Health Events (Occupational) (SHE[O]).[25] The original SHE(O) list compiled by Rutstein, *et al*, included industries and occupations that were linked in the literature to a hazard associated with an occupationally related disease. Other industries and occupations might also have the same hazard. Information from JEM now makes it possible to identify this expanded set of workplaces. A recent article by Lalich and Schuster describes the analysis of death certificates currently underway using the expanded SHE(O).[26]

In the same manner, JEM data have been used in conjunction with other national databases, e.g., the National Center for Health Statistics Household Interview Survey (NHIS) and the National Health and Nutritional Examination Survey (NHANES). By linking self-reported hearing loss from NHIS to noise levels measured by NOHS, estimates were made of the joint role of aging and noise in the workplace.[27] Using the NHANES data with a list of workplaces where NOHS indicated a potential exposure to lead, NIOSH investigators found significantly increased blood lead levels in a nationally representative sample of workers potentially exposed to lead.[28]

NIOSH obtained the OSHA Integrated Management Information System (IMIS) files to augment and complement other hazard surveillance databases. IMIS contains the results of OSHA health inspections since 1979 for those states in which OSHA compliance officers operate. The most obvious contribution of these data is the completed environmental sampling and analytic results contained in the file.[29] Although approximately 500 agents are regulated by OSHA, 75 percent of the IMIS data dealt with only 15 compounds. More than 15 percent of all the OSHA samples are collected for lead or lead compounds. Because the majority of OSHA's compliance inspections are conducted in response to complaints or fatalities, the file is not intended as representative, nor can reliable inferences be made to national statistics. A companion paper in this monograph (chapter VI) addresses the feasibility of establishing links between the IMIS file and NOHS/NOES, and JEM.

During this period, NIOSH also began investigating the potential role of computer-based, in-plant surveillance systems in a national hazard surveillance strategy. The emergence of low-cost computers, coupled with increased requirements for surveillance and record-keeping under OSHA's Hazard Communication rule, has resulted in a variety of software products that permit employers to collect, store, and analyze data on potential exposure agents, environmental sampling, and medical testing and treatment of employees.[30,31] Potentially, such systems can produce data for hazard and disease surveillance that supplement observational data collected in national surveys like NOHS and NOES.

Typical Uses of Hazard Surveillance Data

NIOSH receives an average of 200 requests per year for data from NOHS or NOES. Table 1 shows a profile of users over a typical 12-month period.

TABLE 1—User Profile for NOHS/NOES Data Requests (July 1986–June 1987)

Source	% of Requests
NIOSH	45.7
Industry*	23.3
Other federal agencies	14.7
State government	7.8
Academia	4.7
Foreign	2.3
Private citizens	1.6

*Includes government contractors, attorneys, and information vendors.

Because the sample of establishments for NOHS and NOES was designed to permit the development of national statistics from the survey data, estimates can be generated of the number of employees potentially exposed to any of the approximately 9,000 chemical, physical, and biologic agents, and industries and occupations can be identified where those potential exposures occur. Thus, this database is particularly useful as a source of information for assigning priorities to toxicologic and epidemiologic research. In fact, potential exposure estimates from NOHS were used extensively as one ingredient of the algorithm by which NIOSH assigned priorities for topics for its Criteria Documents. The database is also used to profile potential exposure agents associated with particular industry or occupational groups to help develop or sharpen hypotheses suggested by morbidity or mortality surveillance activities. The file of product ingredient information, which was developed in conjunction with the surveys, can also be used as a hazard surveillance tool in its own right. For example, if new toxicologic evidence emerges concerning a particular agent, the product ingredient file can be queried to display all products that contain this agent (and their manufacturers). This information can then be used to identify occupational groups potentially exposed to the agent (manufacturing site and purchasers of the product) for appropriate intervention strategies. Since NOHS was completed, the information it has produced is frequently referenced by Congress, scientific literature, the national press, and in professional conferences. It has provided important input to OSHA's compliance activities by providing the base on which a model for targeting discretionary health inspections was built and implemented. The data were also prominently referenced in the preamble of OSHA's Hazard Communication rule. The chemical selection procedures of the Environmental Protection Agency (EPA), the National Toxicology Program, and the Bioassay and Epidemiology programs of the National Cancer Institute have all made use of NOHS data.

The NOHS and NOES databases are unique because of the wide range of potential exposure agents covered, the representative nature of the sample of establishments, and the approach used to clarify potential exposures to trade-named products. The data play an essential role in virtually any intervention strategy; precisely this sort of prior intelligence on potential exposures is necessary to guide and support the full range of intervention strategies that should follow. When scarce resources must be directed toward problems of the highest priority, NOHS and NOES continue to supply important input to a complex decision-making process.

Future Directions

Periodic, large-scale, national surveys like NOHS and NOES have substantial advantages when compared with alternate sources of hazard surveillance data. The data they produce on many potential exposure agents can be generalized and will support the analysis of temporal trends. The most apparent disadvantages are the cost and the lack of environmental sampling data. Currently no specific plans are underway to conduct a third national survey, although such an approach will undoubtedly be considered with other options at the appropriate time.

An alternative to the periodic survey is a continuing survey that sequences specific segments of industry for survey each year; the survey becomes "complete" after all relevant industries have been surveyed, and then the cycle repeats. A continuing, cycling design has certain advantages because the data are always reasonably current, resource requirements are more predictable and spread evenly over many years, and start-up and phase-out problems are eliminated. The National Occupational Health Survey of Mining (NOHSM) currently in progress is of this type; mines and mills are selected based on commodity groups and sequenced accordingly. The entire survey will require an estimated six years to complete. Retaining surveyors over the course of such a survey is difficult, and costs are at least as high as with periodic surveys.

Another possible strategy would be simply to augment the centerpiece NOHS and NOES databases with smaller special-purpose surveys as needed. Examples of sectors that would complement the existing data are agriculture, small businesses, and emerging technologies. It may even be possible to construct special-purpose surveys that would develop environmental sample data in a smaller set of facilities, perhaps drawn as a subsample of the NOES establishments.

Improving the use of existing databases for hazard surveillance will potentially broaden the capabilities of the hazard surveillance program at very little additional cost. The NIOSH Hazard Evaluation and Technical Assistance activity responds to approximately 500 requests per year. Many of these requests evolve into on-site toxicity determinations with environmental sampling and cross-sectional medial screening of employees. Even though the development of inferential statistics may not be possible from such data, they can function like the OSHA IMIS file as an additional source of information for associating exposures with occupational groups. Tracking the development of data generated by EPA under the Emergency Planning and Community Right to Know Act of 1986 and by the Hazard Communication rule enforced by OSHA will also be important.

Opportunities are potentially great for synergistic interaction between activities in both hazard and disease surveillance.[27,28] The NOHS and NOES databases can be used to expand the number of industries and occupations known to be associated with sentinel health events of possible occupational origin.[26] The systematic use of JEM in the epidemiologic analysis of large data sets can potentially identify previously unrecognized associations between exposure and disease.

Improved dissemination of hazard surveillance data already at hand is a particularly promising strategy for the future. Current strategies for disseminating surveillance data rely heavily on NIOSH Technical Reports, journal articles, presentations at conferences and other meetings, and customized reports developed in response to requests from potential users. Although these strategies do result in a considerable flow of information to recipients capable of using it, substantial opportunities to broaden the base of information available exist in recent advances in the technology of information transfer. In general, surveillance data are fundamentally different from other species of data that NIOSH disseminates. In most cases, the datasets are very large and a commensurately large number of potential analyses are possible. For example, the NOHS and NOES datasets each produced databases of some five million records. Results from these surveys have been widely published, but substantial analytic possibilities still remain. These have been inadequately explored, particularly by researchers outside NIOSH, primarily because of the practical difficulties in transferring files of this size and complexity. Specialized subfiles have been created from NOHS (e.g., JEM) and distributed on computer tape to a wide variety of users, but a large portion of the potential market for these data remains underserved.

Rapid advances in the technology for handling information make it possible to consider a broad array of innovative techniques for disseminating large amounts of data to many users.[32] The proliferation of personal computers makes possible the dissemination of information on floppy disks, and many users of personal computers also possess modems for accessing datasets, either by connecting to mainframe computers or through electronic bulletin boards. Several government agencies have begun to make data available through such channels (Bureau of the Census, Bureau of Labor Statistics, etc.). The capacity of storage media is also improving with the emergence of optical techniques like read-only compact disks (CD ROM), which are being used to disseminate extremely large data files. Disseminating information accomplishes more than simply educating the recipient; it builds channels through which continuing communication can occur. The more channels are created, the easier it will be to obtain current intelligence on occupational hazards and their health effects.

REFERENCES

1. Halperin WE, Frazier TM: Surveillance for the effect of workplace exposures. *In:* Breslow L (ed): Annu Rev Public Health 1985; 6:419–432.
2. Sundin DS, Pedersen, DH, Frazier TM: Occupational hazard and health surveillance. Am J Public Health 1986; 76:1083–1084.
3. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, vol. 1 (2nd ed). NIOSH Pub. 77-157A. Order from National Technical Information Service, Springfield, VA. No. PB-274-845/A99.
4. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, vol. 2 (2nd ed). NIOSH Pub. No. 77-157B. Order from National Technical Information System, Springfield, VA. No. PB-276-624/A99.
5. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, vol. 3 (2nd ed). NIOSH Pub. No. 77-157C. Order from National Technical Information Service, Springfield, VA. No. PB-276-838/A99.
6. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, vol. 4 (2nd ed). NIOSH Pub. 78-175. Order from National Technical Information Service, Springfield, VA. No. PB-83-105-437/A32.
7. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, vol. 5 (2nd ed). NIOSH Pub. No. 79-141. Order from National Technical Information Service, Springfield, VA. No. PB-83-105-445/A22.
8. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, vol. 6 (2nd ed). NIOSH Pub. No. 80-125. Order from National Technical Information Service, Springfield, VA. No. PB-82-157-728/A15.
9. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, vol. 7 (2nd ed). NIOSH Pub. No. 82-100. Order from National Technical Information Service, Springfield, VA. No. PB-83-105-452/A10.
10. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods (3rd ed, suppl). NIOSH Pub. No. 85-117. Order from National Technical Information Service, Springfield, VA. No. PB-86-116-266/A15.
11. Pedersen DH, Young RO, Sundin DS: A Model for the Identification of High Risk Occupational Groups using RTECS and NOHS Data. NIOSH

Pub. No. 83-117, October 1983. Order from National Technical Information Service, Springfield, VA. No. PB-84-190-685/E09.
12. National Institute for Occupational Safety and Health: National Occupational Hazard Survey—Vol. I. Survey Manual. NIOSH Pub. No. 74-127, May 1974, Order from National Technical Information Service, Springfield, VA. No. PB-274-241/A10.
13. National Institute for Occupational Safety and Health: National Occupational Hazard Survey—Vol. II. Data editing and data base development. NIOSH Pub. No. 77-213, July 1977. Order from National Technical Information Service, Springfield, VA. No. PB-274-819/A08.
14. National Institute for Occupational Safety and Health: National Occupational Hazard Survey—Vol. III. Survey analysis and supplemental tables. NIOSH Pub. No. 78-114, December 1977. Order from National Technical Information Service, Springfield, VA. No. PB-82-229-881/A99.
15. Sundin DS: A difficult quest for a reliable data base. Occup Health Saf 1978; 47:21–23.
16. Venable HL: Trade name ingredient data base. *In:* Proceedings of the First NCI/EPA/NIOSH Collaborative Workshop: Progress on Joint Environmental and Occupational Cancer Studies, May 6–8, 1980. DHHS Pub. No. 341-132/3522. Washington, DC: Govt Printing Office, 1981.
17. Venable HL: The Development and Application of Algorithms for Generating Estimates of Toxicity for the NOHS Data Base. Cincinnati, OH: National Institute for Occupational Safety and Health. NIOSH Pub. No. 87-101, July 1986.
18. Frazier TM, Sundin DS: Industrial demographics and population at risk for silica exposures. *In:* Goldsmith DF, Winn DM, Shy CM (ed): Silica, Silicosis, and Cancer. Cancer Research Monographs, Vol 2. New York: Praeger Publishers, 1986.
19. Kreitel KD: Mapping chemical exposures. *In:* Proceedings of the First NCI/EPA/NIOSH Collaborative Workshop: Progress on joint environmental and occupational cancer studies. May 6–8, 1980. DHHS Pub. No. 341-132/3522. Washington, DC: Govt Printing Office, 1981.
20. Frazier TM, Lalich NR, Pedersen DH: Uses of computer-generated maps in occupational hazard and mortality surveillance. Scand J Work Environ Health 1983; 9:148–154.
21. ABT Associates, Inc.: Final Report: Contract to Design Forms and Materials for the Collection of Employer-derived Data. Cincinnati, OH: National Institute for Occupational Safety and Health. NIOSH Contract No. 210-78-0068. April 1979.
22. Sundin DS: The national occupational hazard survey (NOHS II). *In:* Proceedings of the First NCI/EPA/NIOSH Collaborative Workshop: Progress on joint environmental and occupational cancer studies. May 6–8, 1980. DHHS Pub. No. 341-132/3522. Washington, DC: Govt Printing Office, 1982.
23. Seta JA, Sundin DS, Pedersen, DH: National Occupational Exposure Survey Field Guidelines. Cincinnati, OH: National Institute for Occupational Safety and Health, NIOSH Pub. No. 88-106, March 1988.
24. Centers for Disease Control: Trends of a decade—A perspective on occupational hazard surveillance, 1970–1983. *In:* CDC Surveillance Summaries. MMWR 1985; 34(No. 2SS):15–24.
25. Rutstein DD, Mullan RJ, Frazier TM, *et al:* Sentinel health event (occupational): a basis for physician recognition and public health surveillance. Am J Public Health 1983; 73:1054–1062.
26. Lalich NR, Schuster LL: An application of the sentinel health event (occupational) concept to death certificates. Am J Public Health 1987; 77:1310–1314.
27. Centers for Disease Control: Self-reported hearing loss among workers potentially exposed to industrial noise—United States. MMWR 1988; 37:158–167.
28. Centers for Disease Control: Results of blood lead determination among workers potentially exposed to lead—United States. MMWR 1983; 32:216–219.
29. Froines JR, Dellenbaugh CA, Wegman DH: Occupational health surveillance: a means to identify work-related risks. Am J Public Health 1986; 76:1089–1096.
30. Finucane RD, McDonagh TJ: Medical information systems roundtable. JOM 1982; 24:781 ff.
31. The expulsion in health and safety data bases. Chem Week September 1983; 7:22–24.
32. Sieber WK: Researchers' micro analyze hazards. Govt Comput News May 22, 1987.

VIII. Injury Surveillance

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Introduction

In 1986, an estimated 5.6 million work-related injuries occurred in the United States. This represents an industry-wide average case rate of 7.9 injuries per 100 full-time employees.[1] In certain high-risk industries such as fabricated structural metal and meat packing, nearly one-fourth to one-third of the work force experience an occupational injury every year. Roughly 46 percent of all injuries nationwide in 1986 were severe enough to require workers to take time off from work or be restricted in work activity beyond the day of the injury.[1] An estimated 10,700 workers are killed annually by traumatic occupational injuries.[2] The financial cost of these untoward events is staggering; the National Safety Council estimated the fiscal burden of work injuries in America at $34.8 billion in 1986,[2] while workers' compensation premiums cost American industries $60 billion annually.[3] Costs for occupational injury affect the viability and competitiveness of an industrial enterprise. The average cost to employers in 1978 for an injury resulting in lost work days was $14,000.[4] The societal burden of occupational injuries can be seen by the proportion of preventable expenditures in the federal budget. Occupationally injured workers who are permanently disabled must—instead of being wage earners—be cared for financially through the social security system and workers' compensation benefits. Fatal injury or permanent disability of a worker with young dependents can result in long-term provision of income maintenance by the federal government for the affected family. Finally, the costs of occupational injuries in human suffering, pain, grief, and lost or shattered lives are inestimable.

The scale of this occupational injury crisis demands that it be classified as a national health problem of catastrophic proportions. The current state of injury control in America may represent one of the greatest failures of our modern society; prevention tools are available but have not been requisitioned at a level commensurate with the size of the problem.[5] By failing to secure sufficient resources to carry out state-of-the-art public health, our nation has been unable to act comprehensively and aggressively to establish well known surveillance and prevention methods that can reduce the burden of occupational injury, disfigurement, disability, and death.[5,6]

This paper examines current concepts in epidemiology and surveillance for occupational injuries. It reviews existing information systems for implementing occupational injury surveillance, discusses strategies for preventive intervention, and entertains proposals for developing comprehensive programs for occupational injury surveillance.

Concepts for Epidemiology and Surveillance of Occupational Injury

Surveillance is defined as "the ongoing, systematic collection, analysis, and interpretation of data related to health. This information is used to plan, implement, and evaluate public health interventions."[7] This definition conceptualizes the monitoring of health-related events so that pertinent intervention or prevention activities can be initiated. Because surveillance is an ongoing process, the monitoring and analysis phase continually assesses preventive intervention procedures and policies for their efficacy in reducing injury.

Epidemiology for occupational injury involves the study of the distribution and determinants of injury in industrial populations which develops the science base for the effective surveillance and control of occupational injuries. This entails:

- describing the population's health status by enumerating the occurrence of injuries, obtaining the relative frequencies of these injuries within groups, and discovering important trends;
- explaining the etiology of injuries by determining the physical, behavioral, organizational, and other occupational exposure factors that cause specific injuries or that are risk factors for them;
- predicting the number of injury occurrences and the distribution of health status within populations; and
- controlling the distribution of injuries in a population by preventing new occurrences (intervention activities that eliminate causal factors through prevention and intervention programs), eradicating existing cases (cure), prolonging life with injury, and otherwise improving the health status of afflicted persons (disability management, vocational rehabilitation).[8]

The common, well-known methods of epidemiology are employed for the etiologic assessment and control of occupational injuries. Descriptive and analytic epidemiology are well-defined sets of statistical techniques and study-design methods for describing the distribution and etiology of injury and disease in human populations. They include the calculation of injury rates associated with exposure hazards: cohort, cross-sectional, and case-control study design methods and the concomitant construction of incidence rate, prevalence rate, and odds ratio risk estimators, ascertainment of relative risks (exposed vs non-exposed injury risk ratios), dose/response curve analysis, statistical significance testing, and multivariable modeling techniques.[8]

NOTE: Author affiliations and addresses are listed on p. 7.

Obviously then, the prerequisite for performing occupational injury surveillance is an information system that provides clear, unbiased data on injury events, trends, etiologic factors (hazards) and risk factors, populations at risk (the number exposed to injury hazards), and trends in injury events in relation to prevention or intervention activities. Although the magnitude of the occupational injury problem suggests an urgent need for surveillance capabilities, no single, comprehensive database currently exists to adequately display injury events for injury epidemiology and surveillance purposes. Indeed, the very magnitude of the problem may delay development of such a system. Data systems currently used to describe occupational injuries were recently reviewed for their epidemiologic and surveillance efficacy and were found to be deficient in many of these key areas.[6,9] Existing systems on occupational injury do represent an opportunity to begin piecing together a program of occupational injury epidemiology and surveillance at the state and national level. Over time, a nationwide, comprehensive program for occupational injury surveillance may evolve through innovative use of these databases and by building on existing programs to create new surveillance information systems.

Existing Databases That Present Surveillance Opportunities

Several databases currently exist and present opportunities for injury surveillance at the state and federal level. Some are purely demographic in nature, while others are health-outcome oriented. A few combine some notion for coding causal factors along with a health-outcome description. This section reviews these systems, discusses their limitations, and suggests improvements to illustrate their use as part of a comprehensive surveillance program. Finally, a demonstration using some of these information systems in their current configuration will illustrate targeted surveillance analysis and intervention opportunities.

Demographic/Denominator Datasets

Employment and Wages Program (ES-202)—The ES-202 program of the Bureau of Labor Statistics (BLS) is a cooperative, information-gathering system between BLS and employment-security agencies in all 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands.[10] This program of gathering statistics on employment and wages serves as a comprehensive source of employment data by industry and provides a virtual census of nonagricultural employees and their wages (approximately 40 percent of agricultural workers are covered in the survey).[10] Quarterly reports processed by the state agencies are forwarded to BLS for summation into a national report of employment and wages by industry. Raw data at the state level are highly detailed, indicating employment and wage information by establishment. An establishment is defined as an economic unit producing goods or providing services, usually at one location, engaged in one predominant type of activity for which a single, standard industrial classification (SIC) may be applied.[10] Large employers with several facilities in more than one county or in more than one four-digit SIC usually submit separate establishment reports.

This information system can generate an excellent statewide estimate of employment by SIC because of the nearly universal reporting coverage of establishments. These data can be used in two ways for injury surveillance: 1) crude occupational injury rates by SIC can be constructed when employment data are merged with health outcome data (such as workers' compensation) containing SIC indicators; and 2) establishment-specific crude injury rates can be calculated when health-outcome data contain the same establishment identifiers.

Construction of crude injury rates by SIC can be the basis for setting priorities in targeting industries for intensified surveillance and intervention activities. Because the ES-202 system provides a nearly universal capture of all employers, many other industry-based reporting systems use it as a bench mark, and use the establishment identifier to provide establishment-level reports. For example, in Wisconsin, the ES-202 establishment identifier is keyed on every worker's compensation report. Thus establishment-specific, crude injury rates can be constructed by merging the ES-202 employment data by establishment to workers' compensation reports. Injury rates by establishment can then be compared with the all-industry average as well as the establishment's industry (SIC) for relative risk assessment and for setting priorities for surveillance.

Drawbacks to using ES-202 data for injury surveillance include the underrepresentation of agriculture, the provision of only industry-level data, and the lack of further establishment employment estimation by occupation, gender, race, and age. Because only crude injury rates can be calculated, important trends in the data that might otherwise be monitored could be masked.

Occupational Employment Statistics Survey—The Occupational Employment Statistics (OES) Survey of the BLS is a periodic mail survey conducted by state employment security agencies to obtain wage and salary information by occupation from a sample of non-farm establishments.[11] Regularly scheduled surveys follow a three-year cycle covering broad industry groupings (e.g., manufacturing, nonmanufacturing, trade, transportation, communications, utilities, government). Occupational classifications combine code systems of the Dictionary of Occupational Titles (DOT) and the Census Occupation; industry codes follow the SIC system. The survey estimates total employment by occupation and by occupation within industry for the entire nation, for each state, and for selected areas within states.[11] Data at the state level contain establishment-level information on occupational employment.

These data are a primary information source for the BLS Industry-Occupational Matrix (IOM),[12] which illustrates by industry the total employment accounted for by each occupation. These data are used to study changing use of workers by industry over time, for skill-requirement analysis in emerging industries, and for market research.[12]

Both OES and IOM have great potential as denominators for occupational injury surveillance. OES is specified to the establishment level in the states, and occupation within industry population estimates are specified. This kind of detail is needed to properly estimate injury incidence and risk. Unfortunately, the survey is sample-based, limiting its value for constructing establishment-specific estimates. Furthermore, data on the age, gender, and race structure of the industry-occupation group analyzed that are desirable for estimating detailed, industry-occupational, adjusted injury rates are not compiled. Nevertheless, these data could be used to construct crude rates of injury incidence for occupation within industry. Improving the survey to include age, gender, and race elements could result in a comprehensive information system that can provide the necessary detail for estimating adjusted injury-incidence rates.

Census—The decennial census of the US Department of Commerce enumerates estimates of industry and occupation employment nationally and by state. Occupations are coded using the three-digit census occupation classification system, while industry codes are based on the SIC system.[13] Occupational employment estimates are stratified by age, gender, and race, while industry estimates are displayed by gender and race. Census industry and occupation estimates can be used with death certificates that use the same coding structure for surveillance of occupational fatalities.[14] Workers' compensation reports are also coded using the census occupation classification system. Thus age- and sex-adjusted rates of occupational injury can be estimated at the state and county level. On a decennial basis, these are currently the best data for setting priorities of occupations within industries for injury prevention and intervention. The census can also be used to bench mark the Bureau of Labor Statistics' Annual Survey.

Although census data permit an estimation of adjusted injury and injury-fatality rates by occupation, analyses are restricted to the national, state, or county level. Establishment-specific adjusted rates cannot be estimated. In addition, some collapsing of population estimates occurs across occupation and industry categories at the state level to provide better sample estimates in small-frequency categories and to ensure sample anonymity. Thus some loss of occupation detail takes place if rates are to be estimated at the county or state level.

Health Outcome Databases

BLS Annual Survey—The Bureau of Labor Statistics Annual Survey of Injuries and Illnesses is a random sample of 280,000 establishments covering virtually all private employers (excluding self-employed; establishments with fewer than 11 employees; state, federal, and local government agencies; and establishments regulated by other federal safety and health laws).[6] This sample survey is a query of the establishment-based, injury-record-keeping programs required under the Occupational Safety and Health Act. It is based on a summary from the establishment's OSHA 200 log of all recordable instances of injury and illness that occur in the establishment and are further supported on the supplemental OSHA 101 form. This survey enumerates all employer-reported occupational fatalities, illnesses, and injuries involving a loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment beyond first aid.[6] Crude incidence rates are calculated from the ratio of total survey-reported events and the total survey-reported employment/hours worked.

This survey can only be used in the most general sense of surveillance, comparing industry crude injury rates and trends, because no detail is provided on who was injured (occupations; individual risk factors: age, experience, gender, etc.), what caused the injury (injury source, type), or the nature of the injury. Only injury counts are reported along with a crude rate estimate by industry.[6] In some instances, the sample collected at the state level is too small to report industry incidence rates for the state. Thus comparison of industries with the nation is not possible in these states.

Collection of the OSHA 101 form, which has detailed employer-provided injury descriptions, has been proposed by the National Academy of Sciences (NAS) for all hospitalizations and fatalities to obtain a more thorough database of items on the circumstances, events, and injured-worker characteristics of these more serious injuries.[6] In response to the NAS recommendations, the Bureau of Labor Statistics is currently redesigning the Annual Survey reporting program in an attempt to obtain specific injury event detail. Even if the suggested improvements are implemented, however, drawbacks exist to using this system for surveillance: although a particular industry may be identified at high risk for injury, individual establishments cannot be targeted for intervention because Annual Survey data are kept confidential; employers reporting data have different understandings of the record-keeping requirements and this could lead to under- or overreporting and data of questionable quality.[6] Nevertheless, these data are among the best currently available for setting priorities among industries for national injury intervention efforts, and obtaining greater detail on specific injury events will substantially improve the usefulness of the system.

Hospital Discharge/Emergency Rooms (NEISS)/Clinics—The National Electronic Injury Surveillance System (NEISS) is a sample of approximately 60 hospital emergency rooms that report treated workplace injuries.[6,15] This reporting system relies partially on a subset of the American National Standards Institute's (ANSI) Z16.2 method of recording basic facts on the nature and occurrence of work injuries.[15,16] (The full implementation of the ANSI Z16.2 system specifies codes for injury source [e.g., circular saw], type [e.g., caught in], nature [e.g., amputation], part of the body [e.g., thumb], hazardous condition [e.g., inadequately guarded], agency of accident [e.g., circular saw], agency of accident part [e.g., blade], and unsafe act [e.g., cleaning, adjusting moving machine]).[16] Source, type, and part of body are reported in the NEISS system, and coded using ANSI Z16.2. Diagnosis codes substitute for nature-of-injury coding. Occupation and industry are also coded on a subset of admissions in 14 hospitals,[6] and all reporting units have age, gender, and severity of injury coded on the report.

Limitations of the current NEISS system include its sample basis, the incomplete industry and occupation coding, and the lack of linkage directly back to the workplace (establishment). Because of budgetary constraints, the NIOSH Division of Safety Research no longer participates in the financial support of the survey to obtain occupational information.

Expansion of this system should be considered to include all hospital discharge information, complete coding of occupation and industry, and, ultimately, clinics and health maintenance organizations (HMO) on a state- and nationwide basis. An expanded, nationwide NEISS could serve as an excellent program for reporting the health outcome from occupational injury. An important consideration is the inclusion of all sites of health care delivery (hospital, clinic, HMO), because specialty treatment and referral patterns may affect the total percentage of case finding.[6] Linkage of the report back to the workplace establishment would also improve the value of the NEISS system for surveillance at state and local levels.

The NEISS program is unique among all existing information systems because it is based in the health care delivery system, yet it provides information on causal factors as well as health outcome. It contains the elements of the NIOSH proposal for SENSOR (Sentinel Event Notification System for Occupational Risks) which initiates reporting by health care providers of selected occupational conditions to state-based surveillance centers. Under the SENSOR concept, health care providers are chosen to report certain occupational health conditions because of their greater likelihood of seeing these conditions. For example, surgical replantation centers and emergency rooms would be selected to report occupational amputations. Many occupational injuries would easily lend themselves to provider reporting because they very often meet the criteria of SENSOR-event recognition. SENSOR events should be reasonably frequent, easily diagnosable by practitioners having no access to sophisticated diagnostic tests, attributable to work in a high percentage of cases, of reasonably short latency, and potentially reversible following identification. Most acute occupational injuries are frequent, easily diagnosed, easily attributed to the workplace, and have no latency period.

Because event reporting is a form of medical history-taking with which health care personnel are familiar and trained to perform, an added level of data integrity beyond employer-based reporting systems is possible. Coding of health outcome by the International Classification of Diseases (ICD) and ICD-External Injury codes is preferable to the ANSI system using nature of injury and part of body codes because more precise descriptive detail on the pathologic or morbid condition is possible. In addition, the new 10th revision of the ICD, being developed for implementation in 1993, includes more detail for coding work-related factors: Finally, a proposal for more easily identifying and coding occupational injuries in health care delivery systems has been submitted to the World Health Organization committee that is writing the ICD-10 revision.[6] Implementing these suggested additions to the ICD-10 would facilitate capture of health outcomes from occupational injury events in any health care delivery system that uses the ICD-10 diagnostic coding scheme.

BLS Supplementary Data System (SDS—Workers' Compensation)—The Supplementary Data System compiled biannually by the Bureau of Labor Statistics provides information on occupational injuries reported from approximately 30 state workers' compensation systems.[6] In 1988, the program was reduced to 15 participating states. The SDS program partially implements the ANSI Z16.2 system for coding the injury event. Injury source, associated object or source, type, nature, and part of body are coded along with occupation, industry, age, gender, length of employment (e.g., experience) of the injured worker, time of day, extent of disability, and medical and indemnity costs.

The SDS program is perhaps one of the most useful current information datasets for identifying *specific* occupational injury events because it contains information on the person (occupation, age, gender), environment (industry), causal factors (source, type, associated object or source), and outcome (nature, part of body). Workers' compensation reports at the state level also typically refer injury events to the workplace or establishment level. This kind of detail allows industrial hygienists, ergonomists, safety specialists, and epidemiologists the opportunity to conduct workplace evaluations of hazards and causal factors and to provide preventive intervention services on-site.

Although SDS is more detailed than the BLS Annual Survey, several problems constrain its usefulness as a comprehensive system for occupational injury surveillance. First, because state reporting of injury and mortality data from state systems is voluntary, SDS cannot provide national estimates of occupational injury morbidity and mortality. Second, data are derived from employers' reports of occupational injuries to state worker's compensation programs, and employers give varying amounts of detail in the injury description, which in turn affects the ability to code the injury properly. Third, because each state has its own workers' compensation requirements for worker coverage and injury reportability, an event may be reportable and compensable in one state but not in another. For example, states in the SDS program each have unique "waiting periods" for workers' compensation, or number of days that the injured is away from work before a claim is compensable and filed with the state. Waiting periods can vary from 1 to 14 days, limiting the comparability of interstate analyses and preventing the accurate estimation of national injury-specific rates.

In addition, the ANSI Z16.2 coding system has its own inherent problems in modeling and specifying the causes and health outcomes of injury events. The ANSI Z16.2 standard is unsuitable for surveillance needs because it is structured around the results of the event (injury) rather than the multiple, pre-event factors that precipitated the injury. It does not provide a means for recording the sequence of events that led up to the injury or the interactions between the object, conditions, and injured worker.[17] Furthermore, ANSI Z16.2 codes are too general to focus on specific equipment types. For example, when amputations are selected for analysis by source code, the machines, powered and nonpowered hand tools, and metal items fall out as dominant injury sources. There is, however, no specificity or detail for machine type, make, and model, or which specific "metal objects" caused the injury. Similarly, if carpal tunnel repetitive injuries are studied, SDS cases are selected by nature of injury (i.e., diseases of the peripheral nervous system) and part of body (wrist). Thus, specification of the health outcome is general and may not relate to a specific diagnosis because other health conditions could have this same code combination.

These limitations make the SDS system only a starting point for injury surveillance. The system can signal that an event has occurred, but detailed case follow-up (medical reports from health care providers, further analysis of causal factors) is necessary to specify the exact etiologic factors and health outcomes. One program that attempted to accomplish this was the BLS work injury reports (WIR) series. Specific kinds of SDS cases were flagged, and additional information including circumstances, behaviors, company safety practices, employee training and experience were gathered from the injured worker.[6] Although uniform data are gathered on a somewhat homogeneous injury-case series, these analyses lack data on either the hazard, the denominator, or a referent comparison group. One approach for modifying these data into an epidemiologic analysis of causal factors consists of developing an internal referent from within the case series, examining various risk factors by "activity at time of injury" for the factor determining case and referent.[18]

Death Certificates—In cooperation with all 50 states, the National Center for Health Statistics (NCHS) collects standardized data from death certificates.[6] Cause-of-death coding uses the International Classification of Diseases (ICD) system, and provisions are made for notations of underlying and non-underlying cause of death (multiple cause coding). The NIOSH Division of Safety Research has developed the National Traumatic Occupational Fatalities (NTOF) surveillance program for traumatic occupational fatalities by selecting deaths of workers aged 16 and older with a positive response to the "Injury at Work" question, and cause of death "external" or codes E800–E999. Certificates have been obtained for 1980 through 1985 and will be collected through 1990.[14] In addition to cause, death certificates contain demographic information (age, race, gender), as well as the usual occupation and industry of the decedent. Denominator data in the NTOF system uses census estimates, county business patterns, and the census of agriculture for estimating injury fatality rates by industry and occupation.[14] This database can serve as an excellent surveillance system for traumatic occupational fatalities. Limitations of the currently configured system include: 1) the completeness with which each state appropriately uses ICD-E codes when classifying causes of death, 2) the completeness of response to the "Injury at Work" question,[6] 3) the failure of all states to uniformly code occupation and industry on the death certificate, 4) the unavailability of data on the death certificate to specify causes or event sequences that led to the fatality, and 5) the lack of systematic linkage back to the workplace establishment. Linkage of death-certificate data to SDS-workers' compensation data and other reporting systems (OSHA fatality investigations, Mine Safety and Health Administration case reports) is one current way to help derive complete occupational fatality enumeration.[6,19] Finally, only detailed on-site follow-back investigations on the fatality can ascertain the significant causal and risk factors that lead to a fatality.

Fatal Accident Circumstances and Epidemiology (FACE)—The Fatal Accident Circumstances and Epidemiology (FACE) program was initiated by the CDC-NIOSH Division of Safety Research in 1982 to provide technical assistance and to develop additional causal factor information on occupational fatalities. As stated in the introduction of each case investigation, the "goal of these evaluations is to prevent fatal work injuries in the future by studying the working environment, the worker, the task the worker was performing, the tools the worker was using, the energy exchange resulting in fatal injury, and the role of management in controlling how these factors interact."[20] Ten states currently participate in the FACE program, concentrating on the analysis of electrocutions and fatalities associated with confined spaces and falls.

The FACE program is a passive surveillance system focusing on case identification and investigation. Studies through the FACE program provide a systematic method for investigating deaths in the workplace. FACE investigations collect information based on a four-component, injury epidemiologic model which cross classifies the host, energy, agent, and environment associated with the injury into an event-time sequence (pre-event, event, post-event). An important part of all FACE investigations is the development of specific recommendations for preventing a similar type of fatality.[21]

The FACE program, however, is limited to the 10 participating states and the fatality types currently under investigation. Furthermore, the program relies on the voluntary cooperation of medical examiners, state OSHA programs, universities, and state health departments to report an occupational fatality. Nonetheless, the FACE program serves as an exemplary epidemiologic model for the detailed follow-up and assessment of causal factors that result in fatal occupational injuries.

Hazards/Causal Factors

Very little information exists on the national distribution of occupational and industrial hazards that are causal factors for injuries.[17,22] Hazard surveillance in industry has focused on developing chemical-exposure databases for occupational illness surveillance. Thus hazard surveys should be conducted to describe the biologic, behavioral, managerial and physical hazards of the workplace. Although two surveys—the National Occupational Hazard Survey (NOHS) and the National Occupational Exposure Survey (NOES)—focused primarily on the potential risks of chemical exposures as assessed by industrial hygienists, some attention was also given to a few physical hazards (such as noise, etc.).[6]

In addition, the classification of injuries has focused on the mechanics and the event but not the exposures or causal factors that determine the injuries.[17,23] Accordingly, this area represents the most deficient part of existing information systems for surveillance of occupational injuries. Considerable work is necessary, therefore, to design a feasible system that can specify occupations and industries; the biologic, chemical, and physical equipment models; and the behavioral hazards present in the workplace.

Detection/Monitoring Strategies

Despite the caveats and limitations of the existing data systems for surveillance of occupational injuries, these data sets may be used today as starting points for injury surveillance monitoring and targeted intervention activities.

Tables 1–4 are examples of database use for surveillance of carpal tunnel syndrome and amputation in industry and occupation. Tables 1 and 3 display four-digit SIC industry injury rates for potential carpal tunnel cases and amputations. Injury rates were constructed by merging the ES-202 employment survey by industry to the Wisconsin workers' compensation case-history file of claims. These data (Table 1) indicate that for Wisconsin, potential carpal-tunnel-type wrist injuries are concentrated in food processing plants (meat packing) and various specialized equipment manufacturing industries. Analysis of the crude occupational odds ratio of these cases with all other workers' compensation cases (Table 2), further verifies these associations; assemblers, butchers, packagers, and various machine operators all have elevated odds ratios and large case frequencies. Interestingly, data-entry operators, typists, secretaries, and dental hygienists have higher odds ratios but lower frequencies, indicating that although workers in these occupations suffer few injuries because of overall risk or population size, carpal-tunnel-type wrist injuries represent the bulk of their injury experience.

Amputations in Wisconsin are concentrated in major industry group 24, lumber and wood products manufacturing (except furniture), machinery manufacturing, food processing (meat packing and canning) and one construction group (Table 3). The generic occupational classification, "machine operator not elsewhere classified," has an elevated odds ratio

TABLE 1—Wrist Injuries—Potential Carpal Tunnel Cases, Wisconsin Workers' Compensation Cases, 1982–86: Industry SIC, Injury Incidence Rate, and Case Frequency

SIC-Industry	Incidence Rate per 10,000 Workers	Frequency
2011-Meat Packing Plants	75.09	247
3711-Motor Vehicles & Car Bodies	50.90	373
3612-Electrical Equip-Transformers	43.36	103
3469-Metal Stamping NEC	28.07	118
3621-Electrical Equip-Motors & Gen	26.84	83
3519-Machinery, Internal Comb Engines	21.10	208
2022-Dairy Products-Cheese Mfg	12.76	74
3079-Miscellaneous Plastics Products	10.67	85
5411-Grocery Stores	5.20	116
2621-Paper Mills	4.34	64

TABLE 2—Wrist Injury—Potential Carpal Tunnel Cases: Case-Referent Analysis, Workers' Compensation Cases, 1982–86: 1980 Census Occupation Code, Odds Ratio, and Case Frequency

Occupation	Odds Ratio	Frequency
204 Dental Hygienists	16.90	14
385 Data-Entry Keyers	10.95	25
794 Hand Grinding & Polishing Occupations	6.99	16
795 Misc Hand Working Occupations	6.30	79
315 Typists	6.23	21
744 Textile Sewing Machine Operators	6.19	69
786 Hand Cutting & Trimming Occupations	5.76	29
888 Hand Packers & Packagers	3.912	7
745 Shoe Machine Operators	3.69	23
686 Butchers & Meat Cutters	3.49	169
313 Secretaries	2.49	26
769 Slicing & Cutting Machine Operators	2.43	95
688 Food Batch Makers	2.25	45
709 Grinding, Polishing, etc., Machine Operators	2.10	88
389 Administrative Support Occupations, NEC	2.09	30
754 Packaging & Filling Machine Operators	2.07	41
796 Production Inspectors, Checkers, Examiners	2.07	58

TABLE 3—Amputations, Wisconsin Workers' Compensation Cases, 1982–86: Industry SIC, Injury Incidence Rate, and Case Frequency

SIC–Industry	Incidence Rate per 10,000 Workers	Frequency
2448-Wood Pallet & Skid Mfg	25.42	20
2434-Wood Kitchen Cabinet Mfg	16.19	10
2421-Saw & Planing Mills—General	14.70	17
2435-Hardwood Veneer & Plywood Mfg	14.20	13
5093-Scrap & Waste Materials	14.18	15
2511-Wood Household Furniture Mfg	12.71	14
3469-Metal Forging & Stamping NEC	9.27	39
2011-Meat Packing Plants	8.20	27
3599-Machinery Mfg Except Elect, NEC	8.18	33
2013-Sausages & Other Meat Mfg	7.90	19
2431-Fabricated Millwork Mfg	5.96	20
1541-General Contractors, Indust Bldgs	5.71	26
2033-Canned Fruits & Vegetables	5.42	19
3711-Motor Vehicles & Car Bodies	4.36	32
3519-Machinery, Internal Comb Engines	4.06	40
3079-Miscellaneous Plastics Products	4.02	32

(Table 4) and the highest case frequency. Specialized machine operators are at greatest risk, including wood lathe operators, cabinet makers, and punch press and saw machine operators. Production supervisors, mechanics, and industrial repairers also experience elevated odds ratios. A need for training supervisors and for training mechanics and repairers in lock-out tagging procedures during servicing and repair is perhaps indicated for these occupations.

Specific establishments may be identified with these data for evaluation and analysis of on-site causal factors and to implement preventive intervention strategies. Using these data, several candidate establishments have been scheduled for visits in Wisconsin.

Intervention Strategies

Once facilities are identified, further on-site, in-depth evaluations are necessary to assess hazards and causal factors and help develop intervention strategies and evaluation mechanisms. Hazard evaluation can consist of job analysis to determine the relationship between work patterns and the impairment; analysis of the work method (what must be done to perform the task successfully); the work station

TABLE 4—Amputation Occupational Case-Referent Analysis, Workers' Compensation Cases, 1982–86: 1980 Census Occupation Code, Odds Ratio, and Case Frequency

Occupation	Odds Ratio	Frequency
726 Wood Lathe, Planing Machine Operators	17.5	26
657 Cabinet Makers & Bench Carpenters	10.17	13
706 Punch & Stamp Press Machine Operators	8.78	70
727 Sawing Machine Operators	7.58	36
645 Patternmakers, Model Maker, Metal	5.34	5
517 Farm Equipment Mechanics	4.01	14
769 Slicing & Cutting Machine Operators	2.92	42
633 Supervisors, Production Occupations	2.78	35
479 Farm Workers	2.70	27
544 Millwrights	2.61	13
725 Misc Metal, Plastic Processing Machine Oper	2.6	16
686 Butchers And Meat Cutters	2.46	45
704 Lathe & Turning Machine Operators	2.37	13
519 Machinery Maintenance Occupations	2.26	6
518 Industrial Machinery Repairers	2.11	57
567 Carpenters	2.11	51
679 Bookbinders	2.11	7
235 Technicians, NEC	2.08	7
708 Drilling & Boring Machine Operators	2.03	8
634 Tool & Die Makers	2.00	8
637 Machinists	1.83	24
754 Packaging & Filling Machine Operators	1.78	13
779 Machine Operators, Not Specified	1.72	285
777 Misc Machine Operators, NEC	1.45	51

(postural, movement constraints placed on operator by the work station); and tool design.[24,25]

In-depth analyses, comparing task activities (postural movements through job activities) can be performed using case-control analysis techniques[26] to ascertain pertinent risk factors such as repetitiveness, forcefulness, mechanical stresses on the musculoskeletal system, and physical stresses at the task site.[27]

The hazard evaluation can then be incorporated into prevention strategies that use engineering controls, personal protective equipment, improved work practices, administrative controls, or workplace monitoring.[24] Controls are really proposals for intervention, a hypothesis about change affecting the morbidity rate.[24,28] Silverstein identifies four steps for the control of health problems: 1) identifying health problems, 2) identifying risk factors, 3) implementing control measures, and 4) evaluating control measures.[28] Assessing the effectiveness of interventions can consist of observing reduced medical visits; reduced costs; and improved product quality, employee satisfaction, and productivity.[28] Ascertaining these effects, however, is hampered by in-plant sample size, problems with health outcome data (reporting biases, inconsistent record keeping, diagnoses), variability in risk-factor specification, and external environmental changes (economy, production technology).[28] Thus, even though the frequency of a particular injury may be high at the state or national level, analysis at the plant or department level may result in the investigation of rare events. Therefore, multicenter trials are necessary to test intervention studies and observe intervention effects.[29]

Summary and Recommendations

The foregoing discussion described existing data systems for injury surveillance, possible improvements for creating a more comprehensive surveillance program, and current possibilities to target intervention and assessment activities. Based on requirements of epidemiologic surveillance and limitations of the existing occupational injury databases outlined in the discussion above, seven areas, described below, are identified for improving occupational injury surveillance in America.

Denominators

Detailed denominators are necessary to identify populations at risk for occupational injuries.[17,22] Population estimates by age, gender, race, industry, and occupation are needed to construct adjusted and specific rates by these risk modifiers. An accurate estimate of populations at risk and their inherent characteristics is a fundamental requirement in any population-based epidemiologic surveillance program. Ideally, this level of detail would also be provided at the establishment level to target intervention efforts of state-based surveillance in facilities and to focus on specific areas within those facilities.

Hazard Monitoring

The underlying distribution of physical hazards in industry must be clarified to determine the relative importance of the hazards (i.e., population exposed), the contribution of the hazards in producing injury events (hazard attributable risk), and to discover new associations between hazards and injury events.[17,22] Collection of hazard data must allow for the detailed coding of equipment, processes, and workplace physical features.[6,17,22,23] Under a comprehensive system of hazard monitoring, it is necessary to provide detailed product-related information so that the surveillance program can determine whether certain pieces of equipment—by virtue of their design—are over-involved in injuries. This kind of detail has been successfully used by the Fatal Accident Reporting System (FARS) of the National Highway Traffic Safety Administration to determine whether certain makes and models of vehicles pose greater injury potential compared with other vehicles.

Injury Process/Event Coding

The ANSI Z16.2 system of recording injuries must be replaced with a multiple, pre-event coding system that can capture pertinent facts about etiologic factors and their interrelationships for injury causation.[17] Within this classification scheme, detailed coding of product involvement is necessary for linkage back to the hazard-monitoring component of the surveillance system. Systems development should specify two levels of detail: 1) an improved general scheme of coding for all injury types, and 2) a highly detailed coding scheme for specific injury types to use in follow-back investigations.

Reporting of Health Outcomes

Better reporting of health outcomes is needed to delineate clearly the pathologic state caused by the injury event. The capture of all injury events is desirable, regardless of treatment site (hospital inpatient, emergency room, clinic, HMO) to avoid treatment referral patterns that alter the representative nature of the health outcome data.[6] Complete reporting coverage by the community of health care providers, with ICD-10E reporting and ICD-10 coding that indicates injury at work can eclipse the problem of what constitutes a reportable event in various state jurisdictions for workers' compensation. All injuries could be captured, and the possibility exists for better coding of events because it constitutes part of the normal process of health care delivery (taking the patient history).

Fatality Monitoring

Comprehensive fatality monitoring is necessary through studies of death certificates with linkage to workers' compensation, medical examiners' reports, and fatality inspection records to explore development of the optimal system for occupational fatality reporting.[6] Problems encountered in designating "Injury Death at Work" must be studied to determine inability of the current system to attain 100 percent reporting coverage of traumatic occupational fatalities.[6] Programs such as the Fatal Accident Circumstances and Epidemiology (FACE) should be expanded for greater national coverage of events and to further develop the causal epidemiologic model for occupational fatalities. The FACE effort should also expand beyond electrocutions, confined spaces, and fall-related fatalities to cover the broad spectrum of fatal work injuries.

Injury Epidemiologic Modeling/Causal Factors Analysis

Improved analysis of causal factors/modeling of injury epidemiology is a necessary priority for research development. Developments are needed to improve the quality of on-site case-referent analyses and the modeling of causal factors for injury events in general. This priority is closely tied to developing an alternative to the ANSI Z16.2 coding system. Existing models should be evaluated for their value in surveillance monitoring and analyses of on-site causal factors.

Intervention Strategies and Evaluation

Improved intervention strategies and evaluation techniques for the strategies are needed to determine better the effect of interventions on morbidity and mortality. Intervention strategies must have clear linkages to analyses of causal factors. On-site or establishment-level interventions often result in the analysis of a micro area where small sample sizes prevent the clear demonstration of intervention effects. Studies must be undertaken to ascertain the efficacy of a multi-center approach of "clinical trials" to assessing interventions.

REFERENCES

1. Bureau of Labor Statistics: Occupational Injuries and Illnesses in the United States by Industry, 1986. NEWS, BLS Release. Washington, DC: Department of Labor, November 12, 1987.
2. National Safety Council: Accident Facts, 1987 ed. Chicago: National Safety Council, 1987.
3. Cudworth A: The insurance industry. The 1987 Conference on Injury in America. Public Health Rep 1987; 6:665.
4. Sheridan PJ: What are accidents really costing you? Occup Hazards, March 1979; 41–43.
5. National Academy of Sciences, Committee on Trauma Research: Injury in America: A Continuing Public Health Problem. Washington, DC: National Academy Press, 1985, 1987.
6. National Academy of Sciences: Counting Injuries and Illnesses in the Workplace. Proposals for a Better System. Washington, DC: National Academy Press, 1987.
7. Klaucke DN, Buehler JW, Thacker SB, *et al:* Guidelines for evaluating surveillance systems. MMWR 1988; 37(suppl 5):1–18.
8. Kleinbaum DG, Kupper LL, Morgenstern H: Epidemiologic Research—Principles and Quantitative Methods. Belmont, CA: Lifetime Learning Publications, 1982.
9. Baker EL, Melius JM, Millar JD: Surveillance of occupational illness and injury in the United States: current perspectives and future directions. J Public Health Policy 1988; 9:198–221.
10. Employment and wages covered by unemployment insurance. *In:* US Dept of Labor: BLS Handbook of Methods, Vol 1, Ch 5, Bulletin 2134–1, 1982.
11. Occupational employment statistics. *In:* US Dept of Labor: BLS Handbook of Methods, Vol 1, Ch 3, Bulletin 2134–1, 1982.

12. National industry-occupational matrix. *In:* US Dept of Labor: BLS Handbook of Methods, Vol 1, Ch 20, Bulletin 2134–1, 1982.
13. The 1980 Census of Population: Classified Index of Industries and Occupations (PHC80-R4). Washington, DC: Govt Printing Office, 1982.
14. NIOSH, Division of Safety Research: National traumatic occupational fatalities, 1980–1984. Morgantown, WV: National Institute for Occupational Safety and Health, 1987.
15. Coleman PJ: Injury surveillance: a review of the data sources used by the division of safety research. Scand J Work Environ Health 1983; 9:128–135.
16. ANSI: Method of Recording Basic Facts Relating to the Nature and Occurrence of Work Injuries. New York: American National Standards Institute, 1969.
17. King K: Feasibility of securing research-defining accident statistics. NIOSH Pub. No. 78-180. Available from National Technical Information Service, Springfield, VA. No. PB-297-814/A14.
18. Coleman PJ: Epidemiologic principles applied to injury prevention. Scand J Work Environ Health 1981; 7(Suppl 4):91–96.
19. Colorado population-based occupational injury and fatality surveillance system report. Denver: Colorado Department of Health, 1987.
20. Conroy CS, Braddee RW, Bender TR: Fatal Accident Circumstances and Epidemiology. Report FACE-87-84. Morgantown, WV: National Institute for Occupational Safety and Health, November 1988.
21. FACE Research Protocol. Morgantown, WV: National Institute for Occupational Safety and Health, December 1988.
22. Coleman PJ: Descriptive epidemiology in job injury surveillance. J Occup Accidents 1984; 6:135–146.
23. Kraus JF: Epidemiology, an academic perspective. The 1987 Conference on Injury in America. Public Health Rep November–December 1987; 6:591–592.
24. Habes DJ, Putz-Anderson V: The NIOSH program for evaluating biomechanical hazards in the workplace. J Safe Res 1985; 16:49–60.
25. Keyserling WM, Chaffin DB: Occupational ergonomics—methods to evaluate physical stress on the job. Annu Rev Public Health 1986; 7:77–104.
26. Armstrong TJ, Lifshitz Y: Evaluation and design of jobs for control of cumulative trauma disorders. *In:* Chaffin DB (ed): Ergonomic Interventions to Prevent Musculoskeletal Injuries in Industry. Chelsea, MI: Lewis Publishers, 1987.
27. Fine LJ, Silverstein BA, Armstrong TJ, Anderson CA, Sugano DS: Detection of cumulative trauma disorders of upper extremities in the workplace. JOM 1986; 8:674–678.
28. Silverstein BA: Evaluation of interventions for control of cumulative trauma disorders. *In:* Chaffin DB (ed): Ergonomic Interventions to Prevent Musculoskeletal Injuries in Industry. Chelsea, MI: Lewis Publishers, 1987.
29. Guyer B: Directions for research and development in prevention. The 1987 Conference on Injury in America. Public Health Rep November–December 1987; 6:656–657.

IX. Occupational Disease Surveillance with Existing Data Sources

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Introduction

Data on disease collected by federal and state groups for surveillance or administrative purposes may also be a relatively easy and efficient means of surveillance of occupational disease. However, two major aspects of these data usually limit their usefulness for occupational disease surveillance. First, conditions related to occupational exposure must be included in the data system, and must be found with some regularity in the geographic area under surveillance. Second, information on the occupation or employment setting of persons in the data system must be included or accessible in some manner.

The availability of employment information varies among federal and state health and administrative data systems. Although occupation and industry information is collected for many of the data systems, inconsistencies in the collection or processing of these data limit their use for occupational disease surveillance. In this paper we will discuss several useful sources of data including state death certificates, cancer registries, state workers' compensation files, hospital discharge records, and other health data sources. We will describe each data source briefly and discuss its advantages and disadvantages.

Occupational Mortality Surveillance

Although England and Wales have used death certificates as a national surveillance system for occupation-related mortality for many years,[1,2] the United States has conducted only one national occupational mortality study.[3] It is more common in the United States for state health departments to conduct occupational mortality surveillance.[4] The pioneering efforts of Dr. Samuel Milham in his studies of occupational mortality in Washington State[5,6] established the feasibility and utility of this approach on a state-specific basis.

Since early 1981, a significant effort has been undertaken to establish a national system for surveillance of occupational mortality. With the support of the National Institute for Occupational Safety and Health (NIOSH), the National Center for Health Statistics (NCHS), the National Cancer Institute (NCI), and the Bureau of the Census, 40 states and the District of Columbia (Figure 1) have initiated efforts to code information on the industry and occupation (I & O) of decedents. Starting in 1988, 23 of these states provide decedent I & O data to NCHS in machine-readable form for analysis and dissemination (Figure 2).

Federal support for these state health departments has taken many forms. NIOSH, NCI, and NCHS cooperatively support state efforts to uniformly collect[7] and code[8] the decedent I & O information. In addition to standardizing coding practices, NIOSH developed computer software to support the editing and analysis of the I & O data.[9]

Most analyses of state mortality data are based on sex- and race-specific, age-standardized proportionate mortality ratios (PMR). The PMR is a summary mortality measure reflecting a comparison of the observed number of deaths for specific causes in an occupation or industry group with the expected number of deaths due to that cause in a standard population. The PMR does not use information on the population at risk.

In investigations of occupational cohorts, the population at risk is typically estimated by enumerating the historical

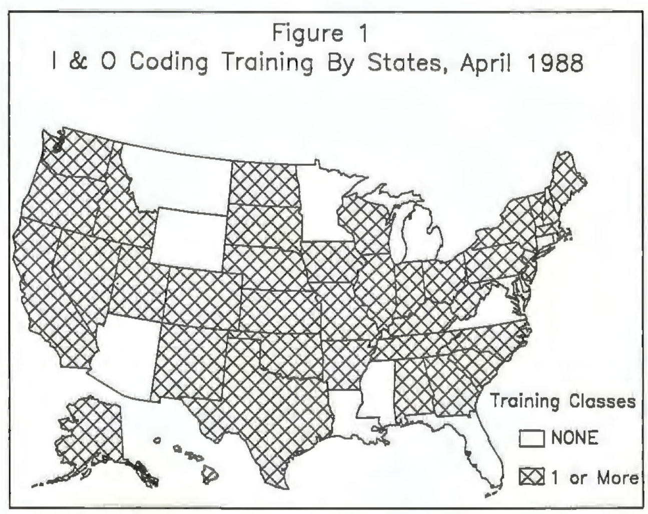

FIGURE 1—I & O Coding Training by States, April 1988
Training Classes: ☐ None; ☒ 1 or More.

NOTE: Author affiliations and addresses are listed on p. 7.

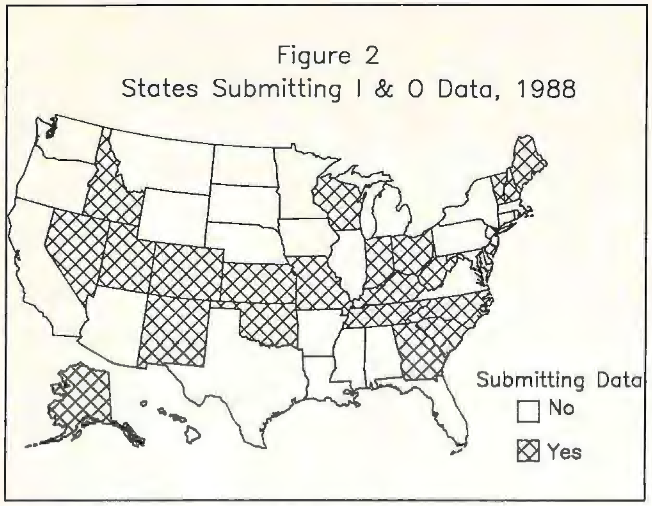

FIGURE 2—States Submitting I & O Data, 1988
Submitting Data: ☐ No; ☒ Yes.

cohort employed at a particular worksite. Census data, the estimated number of people employed within a particular industry or occupation, is another source of population at risk data. Among state-based PMR studies of occupational mortality, the "standard" population is usually the total population of deaths for that study. Information on occupation and industry are obtained from the death certificate and coded using adaptations of the 1980 US Bureau of the Census system for the classification of occupation and industry.[10]

The PMR is a well accepted epidemiologic measure for the surveillance of occupational mortality. Through reanalysis and careful interpretation, PMR analyses identify occupational or industrial groups with possibly increased risk from cause-specific mortality (i.e., hypothesis generation). For states with heavy concentration of a particular occupation or industry, PMR analyses may permit the identification of unusual associations between that occupation or industry and cause-specific mortality. Such an approach has been used in Rhode Island for the jewelry industry,[11] in Iowa for farmers,[12] and in Washington State for aluminum-reduction workers and the paper and pulp industries.[13] However, to the extent that "usual" employment is measured by death certificate data, one should question whether excess mortality relates to current data or past workplace hazards. Disease latency presents some problems of interpretation, particularly if the state or region has undergone fundamental changes in its industrial base.

Surveillance of occupational mortality is particularly important for evaluating cause-specific mortality risks among small businesses or industries or among occupational groups not otherwise amenable to traditional methods of cohort mortality study. For example, an excess risk of bladder cancer among service station attendants was observed in several state occupational mortality studies[14]; increased lung cancer mortality was observed among California workers in the automobile repair industry[15]; and several cancer types were observed to be significantly increased for janitors and cleaners in New York State.[16] Each group is exposed to multiple toxic substances and is difficult to study using traditional cohort methods. Table 1 presents statistically significant and elevated PMRs for site-specific cancer from a study of occupational mortality for the period 1980–82 in Upstate New York. A casual review of the table provides a sense of the common findings in these reports of occupational mortality surveillance.

Investigators should, however, recognize the limitations of occupational mortality surveillance. As discussed previously, the PMR does not use information on the population at risk and is dependent on some standard population for computations. Other statistical methods such as the mortality odds ratio (MOR) may be useful in overcoming these limitations.[17] Interpretation of the PMR requires additional information on the suspect industry and occupation. Detailed information on specific exposures or hazards may be neither available nor imputed from exposure or hazard databases (NOES/NOHS reference). The PMR is based on the entry of "usual industry and occupation" on the death certificates. However, usual I & O may not accurately represent the employment history of the decedent[17–20] and analysis may miss previous jobs where significant exposures occurred.

The process of classifying and categorizing information and industry influences data interpretation. An underlying assumption is that occupation or industry titles are reasonable indicators of occupational exposures and risks. Broad occupation or industry categories may obscure the detection of increased mortality due to specific exposures among particular occupations or narrowly defined industrial sectors. Similarly, a specific exposure or occupational risk may cause increased mortality and not be recognized because the job titles or industrial setting are grouped to reflect the classification system rather than exposure potential.

The choice of the death certificate also presents other limitations. Although surveillance for the underlying cause of mortality will identify work-related disease that is sufficiently serious to result in death, information about contributing causes of death will not be available. For example, the contributing conditions "chronic lung disease" or "neurologic problems" may be either excluded or only partially evaluated. Efforts to have multiple conditions reported on the death certificate may partially address this problem.[21] The completeness and accuracy of the diagnosis for underlying and contributing conditions are also important, but the examining physician often does not recognize many specific work-related diseases (e.g., silicosis and asbestosis) that may contribute to the cause of death.

Surveillance of occupational mortality by state health departments has several advantages as a component of a national program for surveillance of occupational disease. First, mortality surveillance is an efficient use of information routinely collected and processed at state and local levels. The cost is modest to ensure good reporting, processing, and analysis of this information. Second, analysis and evaluation of mortality differentials by occupation and industry provide an index of health status for employed segments of the population. More importantly, detailed evaluation of these differentials permits the monitoring of known occupational conditions and the identification of increased cause-specific mortality for specific industry and occupation groups. The latter may lead to field investigation and then to efforts for controlling potential exposures or occupational risks.

Efforts are needed to improve the usefulness of information produced from a surveillance system for occupational mortality. Quality-assurance activities within the vital statistics programs should be expanded to ensure the specificity and quality of the industry and occupation information. We also need improved methods to evaluate better and interpret the occupational mortality data, and information on the

TABLE 1—Standardized Proportional Mortality Ratios by Cause of Death and Occupation, Upstate New York Males 1980–82

Cause of Death	Occupation	Observed	Expected	SPMR
Cancer: lip, oral cavity and pharynx	Laborers, except construction	30	15.58	1.9249
	Management related occupations	12	9.03	1.3289
Cancer: esophagus	Machinists	12	6.95	1.7274
	Construction laborers	13	7.75	1.6764
	Carpenters	10	5.99	1.6691
	Janitors and cleaners	21	13.90	1.5113
	Laborers, except construction	19	12.68	1.4980
	Management related occupations	10	7.77	1.2866
Cancer: stomach	Supervisors: production occupations	19	10.79	1.7614
	Machinists	13	9.16	1.4188
	Carpenters	10	7.82	1.2791
	Supervisors and proprietors, sales	13	11.25	1.1556
	Janitors and cleaners	20	18.09	1.1059
Cancer: colon	Mathematical and computer scientists	10	2.24	4.4593
	Postsecondary teachers	10	4.23	2.3640
	Managers: marketing, advertising, public relations	12	6.53	1.8372
	Electrical and electronic engineers	11	6.57	1.6749
	Police and detectives, public service	16	9.60	1.6664
	Management related occupations	36	24.85	1.4489
	Taxi drivers and chauffeurs	10	7.49	1.3351
	Electricians	16	12.07	1.3254
	General office clerks	11	8.54	1.2885
	Supervisors: production occupations	34	26.67	1.2749
	Machinists	26	22.33	1.1643
Cancer: pancreas	Supervisors: production occupations	30	15.97	1.8789
	Management related occupations	21	14.77	1.4222
	Machinists	18	13.71	1.3668
	Supervisors and proprietors, sales	21	16.48	1.2746
	Sales representatives, mining manufacturing and wholesale	10	7.87	1.2704
	Janitors and cleaners	29	26.45	1.0965
Cancer: larynx	Janitors and cleaners	10	8.16	1.2254
Cancer: trachea, bronchus and lung	Crane and tower operators	18	9.87	1.8240
	Separating, filtering and clarifying machine operators	11	6.46	1.7034
	Groundskeepers and gardeners, except farm	36	22.67	1.5883
	Railroad conductors and yardmasters	11	7.31	1.5044
	Plumbers, pipefitters and steamfitters	63	42.16	1.4944
	Furnace, kiln and oven operators except food	18	12.05	1.4943
	Brickmasons and stonemasons	29	20.62	1.4067
	Mail carriers, postal service	38	27.04	1.4051
	Barbers	11	7.91	1.3901
	Carpenters	94	75.52	1.2448
	Supervisors: production occupations	127	105.95	1.1986
	Truck drivers, heavy	197	164.37	1.1985
Cancer: bone, connective tissue, skin	Elementary school teachers	10	2.50	4.0014
	Students	12	6.47	1.8539
	Management related occupations	12	8.75	1.3709
Cancer: other genitourinary organs	Supervisors and proprietors, sales	15	10.80	1.3893
	Management related occupations	13	9.78	1.3291
Cancer: bladder	Janitors and cleaners	21	10.27	2.0452
	Supervisors and proprietors, sales	10	6.28	1.5922
Cancer: kidney	Supervisors, production occupations	11	7.40	1.4874
	Truck drivers, heavy	13	11.52	1.1285
Cancer: other and unspecified sites	Secondary school teachers	10	3.29	3.0387
	Sales representatives, mining manufacturing and wholesale	23	11.68	1.9684
	Taxi drivers and chauffeurs	11	6.94	1.5846
	Students	11	7.19	1.5298
	Supervisors and proprietors, sales	34	24.72	1.3753
	Supervisors: production occupations	29	23.06	1.2578
	Automobile mechanics	15	12.23	1.2264
	Plumbers, pipefitters and steamfitters	11	9.49	1.1586
Hodgkin's disease	Students	16	5.48	2.9223
Myeloid leukemia	Truck drivers, heavy	15	7.83	1.9166

underlying and contributing condition should be evaluated.

Using data from the National Occupational Hazard Survey, NIOSH is developing a job exposure matrix to help identify or impute exposures to industries and occupations. A job exposure matrix should prove useful in the preliminary interpretation of occupational mortality data by providing information on potential exposures, physical hazards, and the use of technology to reduce the risk of worker exposure. The matrix may also help classify decedents for directed studies of cause-specific mortality and specific exposure (see Chapter VII in this monograph) and should enable analysis to define groups better for exposure potential.

Cancer Registries

Cancer registries, particularly population-based cancer registries, represent another source of information for occupational disease surveillance. A registry stores information on all cancer cases diagnosed and reported in a given geopolitically defined area. Typically, the registries contain detailed information on the particular cancer (morphology and histology), cancer patient demographics (age, race, sex, residence, etc.), and the end results (treatment, recurrence, survival).

Although I & O information has not been collected consistently for cancer patients, cancer registries have demonstrated a potential for the surveillance and identification of occupational cancer.[22,23] Without occupational information, cancer registries may be used to "screen" occupationally or industrially defined cohorts for risks of site-specific cancer.[23] Screening contrasts with the usual practice of using these registries as case sources for case-comparison studies of possible occupation-related risks. The latter approach has proven useful for evaluating potential risks of occupational cancer, although such studies require more resources than do traditional screening activities.

The findings of case-control studies of occupational cancer have led to increased interest in improving the availability and quality of occupational information in cancer registries. NIOSH has supported statewide cancer registries in Maine, Massachusetts, and Pennsylvania for collecting and processing occupational information on cancer patients. Connecticut officials have recently decided to routinely collect information on smoking, occupation, and industry for all cases reported to the Connecticut Cancer Registry.[24] However, most cancer registries lack information on the employment histories of patients and on many cancer risk factors (e.g., smoking, alcohol consumption). Although the absence of risk-factor information may not pose significant problems for the purpose of occupational cancer surveillance, the absence of information on employment history represents a major current deficiency for the use of cancer registries.

NIOSH has supported two research grants to evaluate the collection of occupational information through population-based cancer registries. It is premature to comment on the progress yet, particularly when we contrast this experience with comparable efforts to develop a state-based surveillance system for occupational mortality. Nevertheless, cancer registries should be considered and developed as an added resource in a nationwide program for occupational disease surveillance.[25]

Workers' Compensation Systems

An evaluation of workers' compensation laws carried out by the National Industrial Conference Board in 1987 recommended that "states should promptly undertake . . . the establishment of a permanent, scientific, uniform system of compensation statistics."[26] Despite the recognized need for a system to organize compensation data and the existence of workers' compensation systems in all 50 states and the District of Columbia, it was not until 1976 that the Bureau of Labor Statistics (BLS) began collecting data on occupational injury and disease from these sources.[27,28] The Supplementary Data System (SDS) of the BLS was designed to collect these data. By 1983, 30 state labor departments were providing uniform sets of information on occupational injuries and illnesses in conformity with SDS reporting requirements.[28]

From the onset SDS faced formidable challenges because the compensation coverage and reporting requirements varied widely from state to state. These vast differences have severely restricted the use of this data set for generating national statistics. Some states submit only closed compensation cases (claims adjudicated in favor of the claimant); other states submit all claims filed whether they are awarded or not, and still others require a minimum number of lost workdays before reporting the claim to SDS.[28] The potential impact of these differential reporting requirements can be seen in the contrast between Kentucky, which reports all claims and had 888 claims for anthracosis in 1980, and neighboring Virginia, which reports only closed cases and had 10 claims for anthracosis or pneumoconiosis in 1980.

Another limitation to the use of data from compensation systems stems from variations in physician reporting practices,[29,30] which in turn stem from underrecognition of these conditions by the medical community[31] and the long latency of many chronic diseases. The effect of all these limitations is more pronounced in the area of occupational diseases because disease claims are more frequently contested than are injury claims.[26,32]

Despite these limitations, compensation systems do contain substantial information useful in identifying worksites with current health hazards. Workers' compensation claims contain not only demographic information from the claimants but also their industry/occupation, the nature of the illness, the source of the problem, the number of lost workdays, and the name and address of the plant where the illness occurred.[33] In 1985, 31 states maintained compensation records in a machine-readable format.[34] Health departments in eight of the states reportedly analyze workers' compensation data independent of any analysis done by the labor departments.

Based on workers' compensation claims for occupational diseases, the State of Washington initiated a successful program of plant inspections in 1977.[35] Similar efforts have been made in Ohio to follow up compensation reports of lead poisoning and cumulative trauma disorders.[33,36] Studies of the epidemiology of electrocutions and electrical injuries in Virginia,‡ logging fatalities in Washington,[37] cold injuries,[38] dermatitis, and work-related violent crime injuries in Ohio[39,40] have all used workers' compensation claims.

When workers' compensation data have been focused on diseases or conditions that are easily recognized and occur without long latency, they have proven useful in identifying worksites appropriate for follow-up actions. Changes in the type of data collected in these programs, better access to the

‡Jones JE, Armstrong CW, Wooland CD, Miller GB: Fatal occupational electrical injuries in Virginia, 1977–1985. Submitted for publication.

data, follow-up investigations, and effective control measures will increase the value of these data for surveillance and for preventive purposes. Workers' compensation data can complement mortality and cancer-registry surveillance by identifying occupational diseases with shorter latencies that are not usually identified in the latter two surveillance systems.

Hospital Discharge Records

Hospital discharge records represent another source of information for the surveillance of occupational disease. Discharge data have been used to identify potential occupational health problems among Minnesota agricultural workers;[41] associate unusual patterns of musculoskeletal disease[42] and leukemia[43] among lumber and wood-product workers; and evaluate the occurrence of selected sentinel health events (occupational) (e.g., extrinsic allergic alveolitis, coal workers' pneumoconiosis, asbestosis, and silicosis) in New Jersey[44] and Rhode Island.[45] No comparable use of these data nationally has been demonstrated.

Discharge data have many advantages as a potential source of information on occupational disease: the information is computerized in many states; the system can be used in state health departments for surveillance of selected chronic occupational diseases; and the system may permit follow-back of cases for detailed investigations.

Although the disadvantages of hospital discharge data are many, they may not be prohibitive for surveillance purposes. Like most information accessed through hospitals, they may contain selection biases for both the disease(s) and the patients admitted for treatment. A patient's discharge abstract is not designed for research purposes, and thus additional medical and risk-factor information may be lacking. Although in many states the information is computerized, the act of processing the data may produce quality problems (completeness, incomparable coding practices), and may inject unnecessary delays between the date of diagnosis and the availability of the data for surveillance purposes.

In general, hospital discharge data present an attractive new source of surveillance information. As noted in a recent National Academy of Science (NAS) study, 20 states computerize discharge abstract records, and nine states have access to these data pursuant to state regulations.[26] In conjunction with the efforts to use cancer registries and workers' compensation files as surveillance tools, increased attention should be directed to the availability and use of hospital discharge data.

Other Data Sources

NIOSH has conducted national studies using information from the National Center for Health Statistics (NCHS)[46–50] and the Social Security Administration.[51–54]

NCHS conducts the National Health Interview Survey (NHIS), a continuing, nationwide survey of American households that collects information on personal and demographic characteristics, health, injuries, and the use of medical care. NIOSH used these survey data in the late 1970s to evaluate unusual patterns of disease and disability for relatively large segments of industry.[46] More recently, NIOSH used NHIS supplements to characterize workers' perceptions of occupational risks,[47] to analyze the prevalence and levels of cigarette smoking for specific occupational groups and segments of industry,[48] and to assess the prevalence of hearing-loss symptoms among adult workers potentially exposed to continuous noise in excess of 85 dBA.[50]

NHIS has been useful for describing and identifying unusual patterns of morbidity for selected industries. The NHIS survey supplement has also been useful for monitoring progress toward achieving broad health promotion and disease prevention goals. In contrast to the data sources discussed previously, these evaluations have not been undertaken to initiate case follow-back and intervention, nor do they provide state-specific surveillance data.

Based on the Current Population Survey through 1984, the NHIS sample was designed to produce national estimates for the civilian, noninstitutionalized population. Changes were made in design, many of which enable NCHS to use this sampling frame for other surveys.[illegible] NIOSH may want to consider the import of these design changes for follow-back studies, possibly using information from NOES to target segments of industry for detailed health surveys.

The NIOSH use of survey data from the Social Security Administration has concentrated on studies of permanent disability. NIOSH has published reports describing patterns of disability in detail for occupation[51,52,54] and industry.[52,53] Until recently, these data have been a largely untapped source of morbidity information, but increased interest has centered on their use for research of stress-related disorders and neurotoxic health effects. As with the NHIS survey data, these disability data sources have not been used for follow-back studies.

Conclusion

The use of existing data sources for surveillance of occupational disease promises to contribute substantially to our recognition and eventual control of occupational diseases in the United States. Increased activity in this area, particularly in occupational mortality surveillance, has demonstrated the utility of surveillance methods implemented at the state level. Increased use and evaluation of other data sources will help expand this surveillance to other conditions.

Several factors must be considered in developing potential data sources. First, efforts to maintain the quality of the data are important. Different data systems emphasize different forms of quality control depending on the type (medical, demographic) or form (hard copy, abstracted, computer file) of the information being processed. Second, improved methods should be developed to link information of specific workplace exposures and the presence of occupational disease. Third, these surveillance systems should not be viewed in isolation. Each should be viewed as part of a system for surveillance of occupational exposure and disease, with each data source complemented by and coordinated with other sources of surveillance information. Different forms of occupational illness may best be identified by different surveillance systems.

Diseases with long latency may be assessed from death certificate or registry sources, and those with shorter latency may be more commonly identified through physician reporting. Similarly, early stages of occupational lung disease may be detected from physician reporting, and later stages may be identified from workers' compensation, hospital discharge, or death certificate sources. More cooperative efforts are needed to understand better the types of occupational diseases identified by different sources of data for occupational disease surveillance.

Finally, these surveillance data should be used to identify and prevent occupational disease. The results of surveillance must be used by groups that conduct detailed field evaluation of occupational health problems because field identification and measurement are necessary first steps in the prevention process.

Prevention programs must be implemented in conjunction with surveillance systems. Our failure to develop better occupational disease surveillance may be due in part to a lack of demand for facility-specific disease data. Current programs for controlling occupational risks should be evaluated with respect to their requirements for medical monitoring and disease reporting. Furthermore, agencies responsible for controlling occupational disease should evaluate the use of surveillance data for targeting workplace inspections.

REFERENCES

1. Registrar General for England and Wales: Occupational Mortality, Decennial Supplement for England and Wales, 1970–1972. London: Her Majesty's Stationery Office, 1986.
2. Registrar General for England and Wales: Occupational Mortality, Decennial Supplement for Great Britain, 1979–80, 1982–83, London: Her Majesty's Stationery Office, 1986.
3. Guralnick L: Mortality by occupation and industry among men 20–64 years of age: United States, 1950. Vital Statistics—Special Reports, Vol. 53, No. 2. Washington, DC: Govt Printing Office, 1962.
4. Dubrow R, Sestito J, Lalich N, Burnett C, Salg J: Death certificate-based occupational mortality surveillance in the United States. Am J Ind Med 1987; 11:329–342.
5. Milham S: Occupational mortality in Washington State, 1950–1971. NIOSH Pub. No. 76-175. Available from National Technical Information Service, Springfield, VA. No. PB-267-289/A06.
6. Milham S: Occupational mortality in Washington State, 1950–1979. NIOSH Pub. No. 83-116. Available from National Technical Information Service, Springfield, VA. No. PB-84-199-769/E09.
7. National Center for Health Statistics: Guidelines for reporting occupation and industry on death certificates. Hyattsville, MD: National Center for Health Statistics, 1988.
8. National Center for Health Statistics: Industry and occupation coding of death certificates. Hyattsville, MD: National Center for Health Statistics, 1987.
9. Lalich N, Schuster L: An application of the sentinel health event (occupational) concept. Am J Public Health 1987; 77:1310–1314.
10. US Bureau of the Census: 1980 Census of the Population, Alphabetical Index of Industries and Occupations. Washington, DC: US Bureau of the Census, 1982.
11. Dubrow R, Gute DM: Cause-specific mortality among Rhode Island jewelry workers. Am J Ind Med 1987; 12:579–593.
12. Burmeister LF: Cancer mortality in Iowa farmers, 1971–78. JNCI 1981; 66:461–464.
13. Milham S, Demers RY: Mortality among pulp and plywood workers. JOM 1984; 26:884–886.
14. Dubrow R, Wegman DH: Occupational characteristics of white male cancer victims in Massachusetts, 1971–1973. NIOSH Pub. No. 84-109. Available from National Technical Information Service, Springfield, VA. No. PB-85-218-683/E09.
15. California Department of Health Services: California Occupational Mortality, 1979–1981. Sacramento, CA: California Department of Health Services, 1987.
16. New York Department of Health: Mortality in New York State, 1980–1982: A Report by Occupation and Industry. Albany, NY: New York State Department of Health, 1986.
17. Miettinen O, Wang J: An alternative to the Proportionate Mortality Ratio. Am J Epidemiol 1981; 114:144–148.
18. Swanson GM, Schwartz AG, Burrow RW: An assessment of occupation and industry data from death certificates and hospital medical records for population-based cancer surveillance. Am J Public Health 1985; 74:464–478.
19. Illis WR, Swanson GM, Satariano ER, Schwartz AG: Summary measures of occupational history: a comparison of latest occupation and industry with usual occupation and industry. Am J Public Health 1987; 77:1532–1534.
20. Steenland K, Beaumont J: The accuracy of occupation and industry data on death certificates. JOM 1984; 26:228–296.
21. Gute DM, Fulton JP: Agreement of occupation and industry data on Rhode Island death certificates with two alternative sources of information. Public Health Rep 1985; 100:65–72.
22. Rosenberg HM: NCHS data resources for studying occupational cancer mortality. *In:* Peto R, Schneiderman M (eds): Banbury Report 9: Quantification of Occupational Cancer. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory 1981; 317–331.
23. Menck HR, Henderson BE: Occupational differences in rates of lung cancer. JOM 1976; 18:797–801.
24. Whorton MD, Schulman J, Larson SR, Stubbs HA, Austin D: Feasibility of identifying high risk occupations through tumor registries. JOM 1983; 25:657–660.
25. Curnen MG, Thompson WD, Heston JS, Flannery JT: Cancer prevention: the tumor registry connection. Cancer Detect Prev 1984; 7:191–199.
26. National Academy of Sciences: Counting Injuries and Illnesses in the Workplace: Proposals for a Better System. Washington, DC: National Academy Press, 1987; 93.
27. Barth PS, Hunt HA: Workers' Compensation and Work-related Illnesses and Diseases. Cambridge, MA: MIT Press, September 1982.
28. US Department of Labor: Injury and illness data available from 1983 workers' compensation records. Announcement 86–1. Washington, DC: Bureau of Labor Statistics, March 1986; 1–6.
29. Disher DP, Kleinman GD, Foster FJ: Pilot study for development of an occupational disease surveillance method. NIOSH Pub. No. 75-162. Available from National Technical Information Service, Springfield, VA. No. PB-267-511/A09.
30. US Department of Labor: An Interim Report to Congress on Occupational Diseases. Washington, DC: US Department of Labor, 1980.
31. Rosenstock L: Occupational medicine: too long neglected. Ann Intern Med 1981; 95:774–776.
32. Selikoff IJ: Disability compensation for asbestos-associated disease in the United States. Report to US Department of Labor, Contract No. J-9-M-9-0165, June 1, 1981; 346–360, 465–518.
33. Seligman PJ, Halperin WE, Mullan RJ, Frazier TM: Occupational lead poisoning in Ohio: surveillance using workers' compensation data. Am J Public Health 1986; 76:1299–1302.
34. Muldoon JT, Wintermeyer LA, Eure JA, *et al:* Occupational disease surveillance data sources, 1985. Am J Public Health 1987; 77:1006–1008.
35. Kleinman GD, Cant SM: Occupational disease surveillance in Washington. JOM 1978; 20:750–754.
36. Tanaka S, Seligman PJ, Halperin W, Thun M, Timbrook CL, Wasil JJ: Use of workers' compensation claims data for surveillance of cumulative trauma disorders. JOM 1988; 30:488–492.
37. Paulozzi LJ: Fatal logging injuries in Washington State, 1977–1983. JOM 1987; 29:103–108.
38. Sinks T, Mathias CGT, Halperin W, Timbrook C, Newman S: Surveillance of work-related cold injuries using workers' compensation claims. JOM 1987; 29:504–509.
39. Hales T, Seligman PJ, Newman SC, Timbrook CL: Occupational injuries due to violence. JOM 1988; 30:483–487.
40. Seligman PJ, Newman SC, Timbrook CL, Halperin WE: Sexual assault of women at work. Am J Ind Med 1987; 12:445–450.
41. Burkart JA, Egleston CF, Voss RJ: The rural health study: a comparison of hospital experience between farmers and nonfarmers in a rural area of Minnesota. NIOSH Pub. No. 78-184. Available from National Technical Information Service, Springfield, VA. No. PB-297-770/A05.
42. Burkart JA: Musculoskeletal diseases in lumber and wood products workers as identified through hospital records surveillance. Am J Ind Med 1983; 4:725–732,743.
43. Burkart JA: Leukemia in hospital patients with occupational exposure to the sawmill industry. West J Med 1982; 137:440–441.
44. Rosenman KD: Use of hospital discharge data in the surveillance of occupational disease. Am J Ind Med 1988; 13:281–289.
45. Kelley BS, Gute DM: Surveillance Cooperative Agreements between NIOSH and States (SCANS) program: Rhode Island 1980–1982. NIOSH Pub. No. 86-107. Available from National Technical Information Service, Springfield, VA. No. PB-236-163/A04.
46. Kaminski R, Spirtas R: Industrial characteristics of persons reporting morbidity during the health interview surveys conducted in 1969–1974: an exploratory review. NIOSH Pub. No. 80-123. Available from National Technical Information Service, Springfield, VA. No. PB-81-168-585/A04.
47. Shilling S, Brackbill RM: Occupational health and safety risks and potential health consequences perceived by US workers. Public Health Rep 1987; 102:36–46.
48. Brackbill RM, Frazier TM, Shilling S: Smoking characteristics of workers, 1978–1980. Am J Ind Med 1988; 13:4–41.
49. Centers for Disease Control: Results of blood lead determinations among workers potentially exposed to lead—United States. MMWR 1983; 32(16):216–218.
50. Centers for Disease Control: Self-reported hearing loss among workers potentially exposed to industrial noise—United States. MMWR 1988; 37:158,164–167.
51. Kennedy J, Fischbach TJ, Green J, Leihy RE: Occupational characteristics of disabled workers: an analysis of social security disability benefit

awards to workers during 1969–1972. NIOSH Pub. No. 80-145. Available from National Technical Information Service, Springfield, VA. No. PB-82-150-798/E03.

52. Osborne R, Fischbach T: Causes of disability in employees of the mining industry: analysis of social security disability benefit awards and allowances to workers, 1969–1973, 1975–1976. NIOSH Pub. No. 85-105. Available from National Technical Information Service, Springfield, VA. No. PB-85-220-556/A06.
53. Fischbach T, Crouse W, Sestito JP, Green JH: Industry and disabling conditions of disabled workers, 1975–1976: analysis of social security disability benefit allowances to workers during 1975–1976. NIOSH Pub. No. 86-105. Available from National Technical Information Service, Springfield, VA. No. PB-86-222-957/A08.
54. Fischbach T, Bacey E, Sestito JP, Green JH: Occupational characteristics of disabled workers, 1975–1976: analysis of social security disability benefit allowances to workers during 1975–1976. NIOSH Pub. No. 86-106. Available from National Technical Information Service, Springfield, VA. No. PB-86-221-413/A10.
55. Kovar MG, Koe GS: The national health interview survey design, 1973–1984, and procedures, 1975–1983. National Center for Health Statistics: Vital and Health Statistics, Series 1, No. 18. DHHS (PHS) Pub. No. 85-1320. Washington, DC: Govt Printing Office, 1985; 9.

X. Surveillance for Work-Related Adverse Reproductive Outcomes

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Introduction

The NIOSH list of 10 leading work-related diseases and injuries in the United States includes disorders of reproduction.[1] Based on the proposed national strategy by NIOSH and the Association of Schools of Public Health for the prevention of disorders of reproduction, it is apparent that surveillance for these disorders—like the epidemiology and toxicology of reproductive disorders—is in an early stage of evolution.[2] Because of an increasing awareness of work-related disorders of reproduction and a perception of risk by the population, a call for action, concerted coordination, and commitment by the public health community are indicated to address these issues.

National strategies for surveillance of reproductive disorders are presently fragmentary and poorly coordinated. A need exists to develop, expand, integrate, and link current surveillance activities in the government, private industry, unions, and academia. In addition to developing existing sources of surveillance information, new and creative surveillance systems for reproductive disorders should also be developed.

There are two possible types of surveillance: surveillance for work-related disorders of reproduction and surveillance for physical and chemical hazards to reproductive health.[2] Disorders of reproduction can be prevented when hazards to reproductive health are controlled. The strategy relies on identifying risks to reproductive health through hazard surveillance.[3] When hazard surveillance identifies the source of a problem and controls are instituted, surveillance for work-related disorders of reproduction can document success in eliminating the hazard.

Surveillance for work-related disorders of reproduction documents the occurrence of these disorders in working populations. Surveillance for hazards to reproductive health identifies potential exposures to the population at risk. This paper covers surveillance for work-related disorders of reproduction; two companion papers in this monograph address hazard surveillance for identifying populations at risk (see chapters VI and VII). We will assume a generic population at risk for the surveillance system discussed here. Thus, when we refer to industry-based surveillance, we assume that an industrial population at risk has been identified.

At the meeting of the NIOSH Surveillance Evaluation Group in December 1987, surveillance activities of NIOSH, other health agencies, state health departments, and private industry were discussed, and modest recommendations were made. The chapter relates to previous NIOSH efforts by focusing on the NIOSH strategy as a guide for reviewing the state of surveillance for reproductive disorders. Because the counting of work-related injuries and illnesses is a difficult task,[4] we cannot hope to address all areas but only expect to focus the thoughts of readers.

Disorders of Reproduction

The spectrum of reproductive disorders that may be associated with parental (maternal, paternal, or both) exposures to environmental agents includes infertility, early fetal loss (spontaneous loss), altered sex ratio, late fetal death, neonatal death, low birthweight, birth defects, developmental disabilities, childhood malignancies, and childhood mortality. This paper will focus on the general concept of surveillance for disorders of reproduction as a counting of reproductive outcomes (whatever their nature) that result from events occurring before or after conception.

Surveillance can be achieved for some disorders through the registration of vital events, such as fetal deaths and births. If relevant information on industry and occupation is incorporated on vital records and is coded, then endpoints such as

NOTE: Author affiliations and addresses are listed on p. 7.

altered sex ratio, late fetal death, neonatal death, low birthweight, and some birth defects can be used to evaluate the experience of individuals in broad industry and occupation categories. Otherwise, vital statistics systems provide only nonspecific, work-related baseline incidence rates. With respect to the vital statistics systems, however, the further the outcome is from the time of exposure, the harder it may be to relate the event to parental workplace exposures. This temporal consideration may limit the usefulness of data on developmental disability, childhood malignancies, and mortality.

Surveillance of early endpoints that occur close to the time of conception or attempted conception—such as infertility and spontaneous abortions—is potentially more informative because of the temporal proximity to exposure in the workplace. On the other hand, early endpoints such as very early fetal death may be difficult to ascertain and therefore difficult to count. Buffler and Aase recommend monitoring populations for spontaneous abortions in conjunction with the use of specific tests to determine the frequency of anomalies among these spontaneous abortions.[5] Various hazards to reproductive health potentially increase the frequency of spontaneous abortions. These include hazards that alter the post-conception maternal environment, impair the preconception ovum genetically, produce genetic or cytologic damage to the early embryo, and damage the sperm. Although the completeness of reporting is still under study, industry-based systems could potentially monitor the early occurring reproductive disorders, such as spontaneous abortion, and vital statistics systems could monitor the late occurring reproductive disorders, such as birth defects and infant mortality.

Historical Background

The public health importance of disorders of reproduction to the growth of society can be traced to the beginning of epidemiologic history. In the 17th century, John Graunt and William Petty suggested:

> "By the proportion between marriages and births, and of mothers to births, may be learnt *what hindrance abortions* and long suckling of children is to the speedier propagation of mankind..."[6]

In the 19th century, William Farr measured the impact of reproductive disorders on population growth by counting their occurrence.[7] Farr aptly observed that reproductive outcomes affect the underlying economic and social fabric of a nation, and their influence can be measured by the actuarial laws and principles that govern the growth of a population. Even though William Farr may have worked out the actuarial effect of reproductive disorders, the process of how to collect surveillance data remains problematic. Disorders of reproduction, such as infertility or spontaneous abortions, may not receive medical treatment and may not be recorded in medical or registration systems. In addition, some disorders of reproduction are not uniformly defined. For example, reduced fertility is difficult to define, and the data required to evaluate fertility are often personal and time-consuming to collect.

Based on the success of traditional public health systems for surveillance of infectious diseases, surveillance for work-related disorders of reproduction is an obvious and necessary step toward understanding the nature and characteristics of work-related disorders of reproduction. Indeed, the goals of surveillance for disorders of reproduction resemble those of surveillance for infectious diseases. The epidemiologic study of infectious diseases depends on surveillance systems that identify and report cases of disease to measure the frequency and impact of infectious pathogens. Similarly, surveillance for work-related disorders of reproduction would provide a method for both detecting their occurrence and monitoring progress toward eliminating the hazard. Once hazard surveillance identifies the population at risk, then surveillance for reproductive disorders can identify adverse reproductive effects in the population. Surveillance for reproductive disorders can be used to construct baseline incidence levels for reproductive disorders just as surveillance for infectious diseases documents baseline endemic disease levels. A major difference between surveillance for disorders of reproduction and surveillance of infectious diseases is the clear association of pathogens with infectious diseases and the lack of known causes for most work-related disorders of reproduction.

Thus, surveillance for disorders of reproduction challenges the traditional public health methods for surveillance of communicable diseases. The ideas of one system cannot simply be adopted to develop the other system. Neither the ease of displaying some of the epidemiologic determinants of person, place, and time (such as age, race, sex, time of onset) for infectious data nor the relative ease of recognizing and reporting infectious diseases holds true in the surveillance of disorders of reproduction.

Obtaining the epidemiologic determinants for counting person, place, and time in work-related disorders of reproduction is more difficult because the surveillance process is confounded by a need to consider both occupational and nonoccupational agents, rank the incidence rate relative to background incidence rates (that may not even exist), and attribute exposure to an event occurring before conception or during pregnancy. Even if a given hazard is known to produce a specific effect and it can appropriately be measured through surveillance, it may not be the only hazard that produces that effect. Questions about the interpretation of surveillance statistics undoubtedly also cloud the issue of how to develop surveillance systems. For example, even if disorders of reproduction were defined unambiguously, the following epidemiologic considerations would still limit interpretation of surveillance results.

- Distinguishing the work-relatedness of disorders of reproduction is complicated because workplace exposures to hazards can be mixed with nonoccupational, environmental exposures and can also be influenced by personal behaviors (e.g., cigarette smoking, alcohol consumption).[8]
- Disorders of reproduction represent an interaction between individual genetic makeup; environmental conditions; and the intensity, duration, and timing of exposure to those conditions. All individuals will not respond in the same way to exposures, and this further complicates the determination of etiologies. Neither gender can be said to be the more vulnerable to reproductive toxicants.
- The causes of these disorders are largely unknown. An agent may be chemical, physical, or biologic and may act independently or in combination with other agents. Any given agent may act as a reproductive toxicant affecting postpubertal reproductive or sexual function, or it may be a developmental toxicant affecting growth, development, or acquisition of normal organ function between conception and puberty.

- Establishing a causal association between workplace conditions and reproductive health is difficult. Most associations studied are nonspecific; a single toxicant can produce a variety of adverse outcomes, or a class of outcomes can result from a variety of different agents.

Historically, the value of surveillance has been in its simplicity and in its capacity to provoke ideas and promote new avenues of thought. Because disorders of reproduction cover a complex spectrum of events, a single surveillance system may not provide adequate data on all outcomes. Nevertheless, several simple systems of surveillance have been used successfully to deal with simple issues of infectious diseases, and these might be considered for reproductive health. In-depth epidemiologic studies should be distinguished from surveillance activities that focus on events rather than on individuals and require timely reporting and feedback.

No historical precedent exists for implementing a national surveillance system for disorders of reproduction. Precedents now being established will be discussed in the following sections. Earlier in this decade, the World Health Organization (WHO) assessed the difficulties involved in addressing reproductive hazards in the workplace. WHO recognized a definite lack of surveillance systems for reproductive disorders; only one published paper among the nearly 200 references cited in the WHO report mentioned surveillance in the title.[9]

NIOSH Surveillance

In 1985, NIOSH discussed reproductive disorders among 10 leading causes of work-related diseases and injuries.[10] This was not the first NIOSH initiative on reproductive disorders; in 1978, NIOSH had stated a commitment to conduct research that would "identify and eliminate reproductive effects due to workplace hazards to workers of either sex."[11] Despite some attempts to develop a national surveillance system, none has yet been developed, and NIOSH typically learns about work-related disorders of reproduction when clusters of specific events, such as spontaneous abortions, occur among employees in a particular work environment[12,13] or, less commonly, through established mechanisms for reporting disorders of reproduction to specialized registries, such as the CDC Birth Defects Monitoring Program.[14] Investigating these reports is difficult because comparative national data for assessing the significance of events are not readily available.[15]

Current NIOSH surveillance of reproductive disorders in employed populations emphasizes development of methods for adapting existing data sources to provide reliable information on maternal and paternal occupation and industry, promote national and state population-based systems, and link data sources. Existing national and regional systems have been improved by standardizing the coding of industry and occupation on vital and health survey records.

NIOSH developed and awarded Surveillance Cooperative Agreements between NIOSH and States (SCANS) to develop capacity within the states for coding industry and occupation on death certificates.[16] Developing the use of existing and new data through programs like SCANS involves standardizing the coding of outcome and employment, increasing reporting, and managing data. Programs like SCANS may have substantial impact because of the population base covered by vital statistics data.

Through the NIOSH SCANS program, coders have been trained to incorporate industry and occupation data in national vital statistics systems. Under these agreements, three states have directed part of their state's activity to vital statistics records on reproductive outcomes. For coding fetal death and birth certificates, interest focuses primarily on the industry and occupation at the time of the event, whereas for coding death certificates, attention centers on the usual industry and occupation of decedents. The occupation and industry of the mother and father would be more relevant for reproductive surveillance involving infant and early childhood deaths. Utah and New York State have analyzed a subset of their data, and Maine is currently evaluating the quality of information on occupation and industry collected and recorded on birth certificates. In addition the State of Washington is currently conducting a review of disorders of reproduction and parental occupation based on vital registration information.

Adapting data from existing vital statistics systems (live births, fetal death, and infant deaths) to define background incidence rates and identify groups of workers with abnormal rates of reproductive disorders is difficult because parental industry and occupation are not routinely coded in national systems of vital statistics data, except in the case of fetal deaths.‡ National data systems offer the advantage of providing population-based estimates for certain disorders of reproduction.

NIOSH has successfully used both the National Maternal and Infant Health Survey[17] and the National Survey of Family Growth,[18] conducted periodically by the National Center for Health Statistics, to calculate national background incidence rates for certain adverse reproductive outcomes.‡‡ The National Maternal and Infant Health Survey is a follow-back survey of live births and fetal deaths reported in vital statistics systems and includes additional information about events and exposures that may be associated with characteristics of live births and fetal deaths. The National Survey of Family Growth is a follow-up survey of women of reproductive age who have been interviewed in the National Health Interview Survey. Additional information is obtained during this follow-up about fertility, pregnancies, and factors associated with fertility and pregnancy outcomes. NIOSH has also used data from state and local health departments to calculate local rates.[19] The 1980 National Natality Survey[20] and the National Fetal Mortality Survey[21] have been used to characterize the occupations of mothers during the year before their deliveries.

State and Hospital-Based Surveillance

The states are in various stages of developing birth defects registries.[14] Currently, one-half of the states have operating systems, one-fourth are developing systems, and the remaining one-fourth have no systems. The operating and developing systems are characterized by diversity, and their purposes range from epidemiologic study to program man-

‡Lalich NR, Salg J, Shilling S: Data sources for adverse reproductive outcomes surveillance: Occupational data. Paper presented at the National Environmental Public Health Conference, 1986.

‡‡Lalich NR, Shilling S: Maternal occupation and industry, and pregnancy outcome in the United States, 1980. Paper presented at 111th annual meeting, American Public Health Association, November 13–17, 1983, Dallas, Texas.

agement. The bulk of the effort, however, is in the surveillance of birth defects.

In addition to developing registries for birth defects, Arkansas has developed a registry for spontaneous abortions. Potential problems may exist in using data from state surveillance systems because these systems differ in their organization, funding authority, populations covered, outcomes surveyed, geographic area covered, method of surveillance, sources of data, analytic methods, and reporting of data. The usefulness of these systems and the importance of data consistency are currently under discussion.

The CDC Birth Defects Monitoring Program compiles discharge data on patients from approximately 1200 hospitals in the United States.[15] The program, which was established in 1974 and relies on voluntary reporting, is the single largest source of information on birth defects in the United States. However, the program does not cover early miscarriages and has no provisions for prospective follow-up of pregnancies. Another surveillance system for birth defects is the Metropolitan Atlanta Congenital Birth Defects Program, also managed by CDC. Since 1967, CDC has tried to record all live and stillborn infants with structural and biochemical congenital defects born to mothers residing in the five-county metropolitan Atlanta, Georgia, area.[22] The value of this system was demonstrated in the study of birth defects associated with occupational exposures among Vietnam veterans.[23,24] Currently, researchers in the Birth Defects and Developmental Disabilities Division of the CDC Center for Environmental Health and Injury Control are seeking to standardize surveillance methods by defining the minimum information needed for all surveillance data sets.

Industry-Based Surveillance

Surveillance systems may be sponsored and implemented by individual companies within a given industry, such as the petroleum refining industry. Although these systems are in their infancy, they are potentially valuable for the surveillance research objective. Industry-based surveillance offers the distinct advantage of conducting surveillance directly where problems exist in the work environment instead of relying on secondary reporting sources in which events may only be reported as a result of medical treatment.

Several investigators have already advocated the use of industry-based surveillance.[5] They suggest that data on fertility, fetal death, congenital malformations, low birthweight, and altered sex ratios can be calculated from existing or slightly modified company databases and compared with available population-based rates that were developed using data systems from the national surveys of the National Center for Health Statistics.

Although industry-based surveillance is a promising new source of data, members of the workforce may be reluctant to provide personal information routinely about either themselves or their spouses on pregnancy status, fertility problems, early fetal loss, or semen characteristics. They are concerned that employers may be tempted to use the data for other purposes, for example, to guide decisions on promotions, transfers, or even terminations. Considering the novel idea of industry-based surveillance and its current use in several industries, appropriate safeguards must be developed to protect the privacy and rights of the workforce so that surveillance can prevent the tragedies of work-related disorders of reproduction.

Recommendations

A major overall recommendation is to use the NIOSH proposed national strategy[3] to guide and focus efforts. This national strategy for achieving reproductive health recommends: 1) increased communication among public health and occupational constituencies, and 2) creativity in approaches, and examination and expansion of existing systems. Specific tasks should be considered as combined activities of government, industry, and labor and of volunteer organizations and university investigators. Reaffirming traditional public health methods for surveillance of communicable disease, these tasks include timeliness of reporting results, focusing on disease events rather than individuals, testing creative approaches for gathering data, coordinating the gathering of data, and evaluating existing systems.

- **Increasing the Quality of Communication**

A national network of public health professionals who are involved in surveillance for reproductive disorders should be augmented by developing a newsletter that reports the results of surveillance. Responsibility for developing the newsletter and a mailing list should be assigned to an agency. Such a vehicle for sharing information gathered through surveillance systems could provide regular reports on surveillance efforts in government agencies, industry, labor groups, volunteer organizations, universities, and others. Over time, the newsletter could evolve into a more formal report that solicits contributions, attempts to review findings in the literature objectively, presents and contrasts more lengthy reports, and presents surveillance data collected from available sources. This activity could also begin to build an archive of tables as a basis for calculating national rates and other measures of reproductive disorders by industry, occupation, environmental factors, and other population characteristics and peculiarities.

- **Encouraging the Development of New and Creative Surveillance Mechanisms**

At this time, a testing of ideas and developing of new systems is appropriate and investigators should try new surveillance mechanisms and compare results with existing systems. They should select an industry-based surveillance system in an area that also has a nonindustry-based surveillance system, monitor the industry-based surveillance system and note its progress and problems, and compare results of the industry-based surveillance with locally collected surveillance data. For example, some companies and some industries have already expressed interest in conducting surveillance for disorders of reproduction following the Digital Equipment Corporation report.[5]

Conclusions

Methods for preventing reproductive disorders in the population as a whole substantially parallel those found in the workplace. As a corollary, a system for surveillance of disorders of reproduction—work-related or not—can be helpful in understanding the epidemiology of work-related reproductive disorders.

Any delay in developing and implementing surveillance for disorders of reproduction may stem in part from a lack of specific outcomes or specific populations at risk identified by hazard surveillance. Diversity in the NIOSH goals and purposes for baseline surveillance of disorders of reproduction reflects a need to consider surveillance as an action item rather than a research need in the NIOSH national strategy.

Surveillance for reproductive disorders is not yet part of the action plan that includes conducting detailed epidemiologic investigations, conducting detailed surveillance for hazardous agents, and encouraging occupational health professionals to work with public and private health organizations to provide educational materials.

Whether trends are identified or disorders of reproduction remain anecdotal may depend in part on the degree of communication within a given industry, the awareness by labor organizations of the problems, or the awareness by investigators of similar problems reported in the literature.

Congress has suggested that surveillance for occupational disease is far behind other disease reporting mechanisms.[25] Surveillance for communicable diseases appears to have all strategic elements in place, such as networks of health departments, lists of notifiable disease, and collaborating laboratories. Unlike systems for communicable diseases, however, surveillance for occupational hazards to reproduction is confounded by hazards in other environments. To build a network for reliable surveillance of work-related disorders of reproduction is a large and challenging task, but clearly current efforts will need to be focused and coordinated.

A first step will be to build a collaborative scientific surveillance community that can evaluate the quality of the data, refine measures of effect and exposure, and develop criteria for interpreting these measures. Passions, prejudices, and opinions may be a source of confusion if they promote an interpretation of events favorable to certain views while weakening the participation of contrary opinions.[26] Quality surveillance can usually dispel illusions that are founded on daily experiences but exaggerated by fears and hopes.

REFERENCES

1. Centers for Disease Control: Leading work-related diseases and injuries—United States. MMWR 1983; 32:24–26, 32.
2. ASPH/NIOSH (The Association of Schools of Public Health under a cooperative agreement with the National Institute for Occupational Safety and Health): Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries, Part 1. Washington, DC: The Association of Schools of Public Health, 1986.
3. National Institute for Occupational Safety and Health: Surveillance in the prevention of leading work-related diseases and injuries: an excerpt of the role of surveillance from the proposed national strategies for the prevention of work-related diseases and injuries. Cincinnati, OH: NIOSH, January 1987.
4. National Academy of Sciences: Counting Injuries and Illnesses in the Workplace: Proposals for a Better System. Washington DC: National Academy Press, 1987.
5. Buffler PA, Aase JM: Genetic risks and environmental surveillance: epidemiologic aspects of monitoring industrial populations for environmental mutagens. JOM 1982; 24:305–314.
6. Greenwood M: Medical Statistics from Graunt to Farr: The Fitzpatrick Lectures for the Years 1941 and 1943, Delivered at the Royal College of Physicians of London in February 1943. Cambridge: Cambridge University Press, 1948.
7. Humphreys NA (ed): William Farr: Vital Statistics, a Memorial Volume of Selections from the Reports and Writings of William Farr. (London: Offices of the Sanitary Institute, 1885). Reprinted with introduction by Susser M and Adelstein A. Metuchen, NJ: Scarecrow Press, 1975.
8. US Congress, Office of Technology Assessment: Reproductive health hazards in the workplace. Pub. No. OTA-BA-266. Washington, DC: US Govt Printing Office, December 1985.
9. El Batawi MA, Fomenko V, Hemminki K, Sorsa M, Verieva T (eds): Effects of Occupational Health Hazards on Reproductive Functions. (WHO/OCH/87.2). Geneva: World Health Organization, 1987.
10. Centers for Disease Control: Leading work-related diseases and injuries—United States. MMWR 1985; 34:537–540.
11. National Institute for Occupational Safety and Health. Proceedings of a workshop on methodology for assessing reproductive hazards in the workplace. April 19–22 1978. NIOSH Pub. No. 81–100. Available from National Technical Information Service, Springfield, VA. No. PB-81–223–521/A18.
12. National Institute for Occupational Safety and Health. Hazard evaluation: immunology branch laboratory. HETA # 82–089–1213. Available from National Technical Information Service, Springfield, VA. No. PB-84–172–535/A03.
13. National Institute for Occupational Safety and Health. Hazard evaluation: Southern Bell. HETA # 83–329–1498. Available from National Technical Information Service, Springfield, VA. No. PB-85–208–379/A02.
14. Flynt JW, Norris CK, Zaro S, Kitchen SB, Kotler M, Ziegler A: State surveillance of birth defects and other adverse reproductive outcomes. Washington DC: Macro Systems, Inc., April 1987.
15. Child Trends Inc: Improving assessment of the effects of environmental contamination on human reproduction: report of findings and recommendations. Grant Number SES-8501616. Washington, DC: National Science Foundation, 1986.
16. Kelly BC, Gute DM: Surveillance Cooperative Agreement between NIOSH and States (SCANS) Program: Rhode Island, 1980–82. NIOSH Pub. No. 86–107. Available from National Technical Information Service, Springfield, VA. No. PB-86–236–163/A04.
17. Banach J, Placek P, Simpson G: AMRA's Role in the 1988 National Maternal and Infant Health Survey. J AMRA 1988;59(10):28–33.
18. NCHS: National Center for Health Statistics Data Line. Survey of Reproductive Health. Public Health Rep 1987;102(6):703–704.
19. Key MM: State and local health departments: forgotten resources in occupational safety and health. JOM 1985; 27:379–385.
20. NCHS, Keppel K, Hensar R, Placek PJ, *et al:* Methods and Response Characteristics—1980 National Natality and Fetal Mortality Surveys. Viral and Health Statistics, Series 2, #100. DHHS Pub. No. (PHS) 86-1374. Washington, DC: Govt Printing Office, September 1986.
21. Ibid.
22. Edmonds LD, Layde PM, James LM, *et al:* Congenital malformations surveillance: two American systems. J Epidemiol 1981; 10:247–252.
23. Flynt JW, Ebbin AJ, Oakley GP, Falek A, Heath CW: Metropolitan Atlanta Congenital Defects Program. *In:* Hook EB, Janerich DT, Porter IH (eds): Monitoring Birth Defects and Environment. New York: Academic Press, 1971.
24. Erickson JD, Mulinare J, McClain PW, *et al:* Vietnam veterans' risks of fathering babies with birth defects. JAMA 1984; 252:903–912.
25. US House of Representatives, Committee on Government Operations, 99th Congress, 2nd session: Occupational health hazard surveillance: 72 years behind and counting. House report 99–879. Washington, DC: Govt Printing Office.
26. DeLaplace M, Essai: Philosophique sur les probabilities, 6th ed. Imprimerie Librarie de Bachelier de L'Ecole Polytechnique, 1840.

XI. The Role of Occupational Health Clinics in Surveillance of Occupational Disease

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Introduction

Occupational disease surveillance may focus on identification of cases to direct interventions toward affected workers and workplaces or on monitoring trends of disease occurrence to plan and evaluate broader prevention programs. (See chapter I in this monograph.) The success of surveillance, regardless of its focus, can hinge on recognition and reporting of work-related disease. Laboratories can be required to report high levels of substances, such as lead, detected through biomedical surveillance programs, and workers may recognize their problems as work-related based on training they received about hazards on the job or the similarity of their disease to that of co-workers. Physician recognition, however, will usually be a crucial aspect of case identification. Yet clinical care for most workers is provided by physicians who are not trained to recognize or manage occupational diseases. Recent surveys document that only half of all the required medical schools in the United States include occupational health in the required curriculum, and even those schools, on average, devote only four hours to the topic.[1,2] In describing the history of training in occupational medicine, Rosenstock states that physicians who have specialized in the field have worked almost exclusively for industry and that physicians who are in general practice have not interacted to any significant degree with these specialists.[3]

The development over the past 10 years of several academically affiliated programs in occupational medicine has the potential to strengthen this weak link in occupational disease surveillance, i.e., case recognition by physicians, and to enhance surveillance in other ways as well. Rosenstock has identified 25 such academic occupational medicine programs that place significant emphasis on clinical services to workers[4]; Navasky has identified 65 occupational health centers that are independent of both industry and labor.[5] The academic programs, which are based primarily in departments of internal or preventive medicine, provide clinical services for the diagnosis and treatment of occupational diseases and emphasize research and health professional training. These programs are multidisciplinary, and their staffs consist of industrial hygienists, social workers, nurse practitioners, and medical subspecialists. Staff members are involved in the social, economic, and legal aspects of patients' problems and are committed to educating workers as well as health professionals. Several of these clinics formed the Association of Occupational and Environmental Clinics (AOEC) in 1987 to promote excellent clinical care for patients who have occupational and environmental diseases and to encourage collaboration in clinical activities and research.

Although this group of clinics is limited in number and geographic scope, it is a unique resource for detecting adverse health effects secondary to occupational exposures. Together these clinics receive over 10,000 patient visits annually; conduct research into the hazards and diseases identified; and provide training for other physicians, students, and workers. The State of Maryland highlighted the importance of such centers in a study on occupational disease reporting; in 1985, two physicians in one academically affiliated occupational disease clinic in Baltimore reported 80 percent of all cases in the entire state.[6] Despite their limited number and the fact that they cannot provide specialty services for the majority of working people in the country, this network of clinics can play important roles in the surveillance of occupational disease.

Five such roles are described in more detail here.

- *Consulting with physicians who report cases to state-based surveillance systems for occupational disease.*

Primary care physicians are very busy and may not have the time to research chemical exposures or to pursue material safety data sheets in caring for patients. A reporting system for physicians must be easy to use and must provide something in return. Using this network of clinics as a resource for local physicians will reduce the burden on the primary care physician and provide expert consultation in return for disease reporting.

For many reasons, physicians may be reluctant to diagnose or report cases of occupational disease. For example, they may lack knowledge of the appropriate treatment for occupational diseases, or they may be concerned that the diagnosis of an occupational disease has legal implications for which physicians have no training. The clinics currently provide expert support for community physicians in managing occupational diseases once they are recognized and advising them about both the medical treatment and the social issues, such as job transfer or workers' compensation. Some clinics have full-time specialists in psychosocial assessment and the management of workers' compensation cases; all have developed these services within their medical centers. As the states develop reporting systems for occupational disease, these centers can assist community physicians in managing all aspects of the diseases detected or can serve as centers for referral. This will assure primary care physicians that their patients who have occupational diseases will be informed of all available avenues for treatment, rehabilitation, and social support.

- *Educating providers to improve recognition and reporting of occupational diseases.*

For a surveillance system to work, primary care physicians must be aware of the occupational causes for disease. The staff physicians in these occupational clinics hold faculty

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appointments at medical schools where they routinely teach practicing physicians, residents, and students. Using the traditional continuing education functions of a university medical center—such as grand rounds, ward rounds in the hospital, and case conferences—they could include specific education for physicians about the recognition and reporting of occupational diseases.

- *Detecting new work-related diseases.*

A major function of these clinics is to evaluate patients' symptoms, diagnose the medical condition, determine whether it is work-related, and institute appropriate therapy. If the cause of an illness is not known but some of its characteristics strongly suggest that it is work-related, the clinic can arrange for a more detailed investigation of both the patient and the workplace. Specific provocation tests for the patient, or evidence of the same disease in co-workers, can lead to recognition of a new occupational disease. By starting with an individual case, the clinics can apply the traditional case-identification and follow-through model used in infectious disease epidemiology to the occupational setting.

These clinics are likely to encounter cases of new or unusual occupational diseases. Whereas contact dermatitis that is secondary to nickel can be adequately recognized and treated by a dermatologist because it is well described in the dermatological literature, hepatitis that is diagnosed in a printer will more than likely be referred to one of the centers. The occupational medicine clinic at Yale University recently described an outbreak of hepatotoxicity secondary to dimethylformamide in which the initial patient was referred to the center because of unusual characteristics of the problem and the suspected presence of the disease in co-workers.[7] Thus, these centers can be a source of significant new data on occupational diseases.

As a corollary, the clinic staff also study the natural history or biologic basis of occupational diseases through research and clinical care. After a disease is identified through the surveillance system, the knowledge gained through such study will help determine what the effective intervention should be.

A computer network between the clinics would enhance recognition of new cases and of the causes of occupational disease. To help create such a network, AOEC is developing a standardized method for coding all patient visits to occupational/environmental medicine clinics. At least four large centers currently have computerized recordkeeping systems, and these are serving as a basis for further development. At a minimum, the records system will log for each individual the diagnosis, the exposure suspected or known to cause disease in that individual, some measure of certainty for an association between the two, and demographic and occupational information. The database will facilitate communication between clinics about new or suspected occupational diseases; and an associated electronic mail system will allow rapid communication between the centers about new hazards and new investigational tools. As a result, a hazard evaluation at one center might be combined with similar investigations at other centers.

- *Disease reporting and technical assistance to state-based surveillance programs.*

In states that have active occupational medicine clinics, the clinics can be one important source of occupational disease case reports. In addition, specialty clinics can serve as centers for referral from state agencies to evaluate cases with uncertain diagnoses reported by other providers. The state can then determine whether an investigation of the workplace is warranted or can combine the clinical information with an inspection to identify the source of the problem. In many states, relationships have been established between the health department and these centers. By developing an ongoing relationship with a center, the agency can be assured of understanding and cooperation.

In addition, after a case of occupational disease has been reported in a state surveillance system, the occupational health clinic can help the state conduct a hazard evaluation of the workplace. Many states do not have occupational health professionals on their staff and need outside consultants to implement public health actions that must follow the report of a sentinel health event.

Several occupational medicine clinics currently collaborate with their state health departments. For example, in Massachusetts, seven clinics are participating in a pilot program* to develop an occupational disease reporting system. The clinics report cases of specified diseases, and the state conducts an investigation of the workplace as appropriate. The state has developed a computerized database to track case reports and sponsors a meeting of the seven centers every two months.

- *Evaluating epidemiologic case definitions for state-based occupational disease surveillance systems.*

The staff in these clinics have extensive experience in diagnosing occupational disease, and they maintain records for many patients with common occupational diseases. Such databases, which are already in place at some clinics and under development for all others, allow easy retrieval of data for all cases of a given disease, such as cumulative trauma disorders or occupational asthma. The existence of these computerized records coupled with a large patient base would make it possible for the clinics to test diagnostic criteria for a specific occupational disease, both retrospectively and prospectively. A retrospective survey could determine whether cases identified by the clinics would have been detected by the proposed criteria; and a prospective survey could determine whether cases not diagnosed at the clinics as occupational would be identified by the criteria. Any differences in diagnosis could then be examined in the context of the goals for the surveillance program: specificity and sensitivity.

As an example, AOEC has worked with NIOSH, using existing records to evaluate a surveillance case definition for occupational asthma, so that the definition can be refined for use in state surveillance systems.

Summary

Academic occupational health centers can support state-based occupational disease surveillance by playing a role in case identification and management, physician education, workplace investigation, and surveillance case criteria development. The existing centers can also serve as models for developing new clinics. As plans for developing surveillance continue, the role of these centers should be explicitly defined, and they should be included in helping to develop mechanisms for reporting. In all these ways, the centers can

*SENSOR, described in chapter IV.

significantly enhance the development of a national surveillance system for occupational disease.

REFERENCES

1. Levy BS: The teaching of occupational health in American medical schools. J Med Educ 1980; 55:18–22.
2. Levy BS: The teaching of occupational health in American medical schools: Five year follow-up of an initial survey. Am J Public Health 1985; 75:79–80.
3. Rosenstock L, Heyer NH: Emergence of occupational medicine services outside the workplace. Am J Ind Med 1984; 6:155–158.
4. Rosenstock L: Hospital-based, academically affiliated occupational medicine clinics. Am J Ind Med 1984; 6:155–158.
5. Navasky LM: A directory of independent workers' clinics. New York: Inform, 1986.
6. Clayson A: Occupational disease reporting in Maryland. Annapolis, MD: Office of Policy, Analysis and Program Planning, Maryland Department of Health, 1985.
7. Centers for Disease Control: Outbreak of occupational hepatitis—Connecticut. MMWR 1987; 36:101–102.

XII. Challenges for the Future

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In this monograph, we have presented a general overview of concepts relating to surveillance and described programs that attempt to improve the capacity for performing surveillance of occupational diseases and injuries in the United States. Various authors have described current efforts in specific areas such as injury surveillance, exposure surveillance, or the surveillance of reproductive hazards while others have critiqued these efforts and have recommended directions for improvement.

The high level of activity over the past several years to improve surveillance is encouraging. As discussed elsewhere in this monograph, congressional committees, a committee of the National Academy of Sciences, the General Accounting Office, and an expert group convened by the Keystone Center have examined various issues relating to surveillance. As a result of this increased attention, programs have been developed.

In considering the future, where are the challenges? How should we define success? In five key areas, criteria for success can be stated, based in part on recent accomplishments, and potential obstacles identified. In so doing, the basis is set for evaluating the efforts of the future and for determining how best to allocate time and resources.

State-Based Surveillance

In recent years, state health departments have been encouraged to improve their capacity to perform surveillance and to focus surveillance efforts in a way that will lead to workplace intervention.[1] Particularly, states have been encouraged to reexamine the role of health-care-provider reporting of occupational disorders through adoption of a model of targeted surveillance followed by worksite intervention. (See chapter IV in this monograph.) Recent reports from states participating in this pilot effort are heartening; providers are reporting, state health departments are analyzing the reports, and follow-up visits to worksites are occurring.

The future success of state-based surveillance will be determined in part by the degree to which disease prevention occurs as a result of active surveillance efforts. As a parameter of success, the degree to which health providers do, in fact, report occupational diseases to state health departments must be used to monitor this process. As a further index of success, the degree to which worksites are visited, coworkers evaluated, and corrective action taken will require documentation.

As interest in occupational health and safety continues to spread, there is reason to be optimistic about expanding this pilot effort to most of the states. In this expansion, federal public health professionals must work to see that those states with strong programs continue to improve while those with weaker efforts overcome gaps in their level of effort.

NOTE: Author affiliations and addresses are listed on p. 7.

Collaboration of Federal Agencies

Three federal agencies have important responsibilities with respect to surveillance of occupational disease and injury: the Bureau of Labor Statistics (BLS) in the Department of Labor, and the National Center for Health Statistics (NCHS) and the National Institute for Occupational Safety and Health (NIOSH), both in the Centers for Disease Control, Public Health Service, Department of Health and Human Services. Some months ago, the three organizations signed a tripartite memorandum of understanding which expressed intention to collaborate in improving national estimates of the true occurrence of occupational disorders. Tangible progress has been made. As an example, a supplement to the 1988 National Health Interview Survey (NHIS) obtained comprehensive information on a variety of occupational disorders and obtained detailed work histories. This project, a joint effort of BLS, NCHS, and NIOSH, represents a model for future surveys of the National Center for Health Statistics in general and the National Health Interview Survey in particular. The three organizations have also collaborated on data sets collected by NCHS through either surveys or vital records analyses. Further collaboration has occurred in developing a methodology for coding of industry and occupation on vital records.

If these accomplishments of recent years are not institutionalized, these achievements will be eroded and information quality will suffer. Particularly within the activities of the National Center for Health Statistics, incorporation of occupational health issues into cyclical surveys such as the National Health Interview Survey is a particularly important goal in obtaining trend data over time. In all surveys, incorporation of occupation and industry information of an historical nature will be useful in obtaining high quality, relevant data at minimum cost. Continuation of the collaboration of these three agencies is essential in utilizing their different types of expertise and data systems.

Exposure Surveillance

Several articles within this monograph address needs to improve exposure surveillance. As described by Sundin and Frazier in chapter VII in this monograph, NIOSH has actively pursued large-scale surveys of representative samples of the US workplace to obtain statistically valid estimates of potential exposure to toxic substances and other workplace hazards. These studies are valuable but very expensive. Further, in view of the magnitude of the effort, the data sets are large and reports are slow to produce.

In considering the challenges of the future in improving exposure surveillance, utilization of existing data sources, such as those provided by the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA), is essential in view of limited resources for surveillance. (See chapter VI in this monograph.) By close interaction with the agency collecting the data, techniques can be modified to improve the utility of the data source for surveillance purposes. Of particular importance, OSHA and MSHA can identify surveillance priorities that complement their responsibilities for assuring compliance with existing regulations. Through such an approach, a targeted exposure surveillance program could provide accurate information in a timely fashion which focuses prevention efforts in areas where the most significant exposures are occurring.

Standardization of Data Collection

Several chapters in this monograph have referred to efforts designed to standardize the approach to collecting surveillance data. Although this topic appears to be one of a purely technical nature, designed to improve reproducibility of collected information, the importance of standardization goes far beyond this utilitarian dimension.

Methods standardization affects professional credibility. In communicating within the field of occupational health and outside it, professionals must be able to specify the nature of occupational disorders. Further, in the conduct of surveillance programs, the approach to collecting data on the occurrence of occupational disorders must be standardized to confirm that "we know what we are looking for." If occupational health professionals cannot specify the problem that is to be prevented, the problem will be either neglected or ignored.

As a result of the pilot effort in state health departments to improve provider reporting of occupational disorders, interest in standardizing case reporting criteria has emerged. (See chapter V in this monograph.) In response to the needs of state health departments, NIOSH convened a subcommittee of its Board of Scientific Counselors and that subcommittee, along with the full Board, approved a case definition for carpal tunnel syndrome (See chapter V, appendix I), which was published in CDC's *Morbidity and Mortality Weekly Report*, vol. 38, July 21, 1989. This effort will be continued with other conditions and represents an important step in standardizing the process of providing case reports to health departments.

In the context of the proposed OSHA generic standard on medical surveillance, other opportunities for methods standardization will arise. In fact, standardization of approach is central to the concept of a generic standard.[2] In its response to OSHA's Advanced Notice of Proposed Rulemaking (ANPR), NIOSH endorsed the concept of methods standardization particularly with respect to the use of health questionnaires and tests of organ system function.[3]

Undoubtedly, this effort will give further impetus to activities underway to develop a standard occupational health survey questionnaire. (See chapter III in this monograph.) Analogous efforts relating to tests of organ system dysfunction should also prove particularly useful. Therefore, experience in the recent past and present activities present a basis for optimism and criteria for measuring the progress of standardization of surveillance methodologies in the future.

Employer Reporting of Occupational Illness and Injury

Undoubtedly, the most difficult area of surveillance is that related to employer reports of illness and injury required by OSHA regulations. Many have expressed concerns regarding underreporting of the occurrence of conditions from this source.[4] Clearly, strong disincentives to report affect the willingness of employers, physicians, other health personnel, and employees themselves to report conditions through this system. Nevertheless, useful information is undoubtedly available and further study of its utility is warranted.

Pilot projects planned by the Bureau of Labor Statistics for 1989 and 1990 will address important methodologic issues but may not address adequately the central issue of data credibility. The efforts of OSHA to issue citations to employers who willfully underreport illnesses and injuries will undoubtedly increase employer attention to this previously neglected area and, hopefully, will improve data quality as a result.

In view of the inherent limitations of employer reporting, parallel data systems must be maintained to assess the degree of underreporting over time. For example, studies performed by NIOSH on the rate of fatal occupational injury using death certificates have been usefully compared with BLS estimates derived from employer reports to identify potential sources of employer underreporting and differences in study design. (See chapter VIII in this monograph.)

Regardless of the utility of employer reports in the enumeration of occupational conditions, the process of recording these events is useful for other purposes. If properly executed, the system may serve the employer by monitoring responsibility to provide a "safe and healthful workplace." Further, through this system, the worker may be notified of the work-relatedness of a specific injury or disease. Although of limited utility for recording of work-relatedness of occupational diseases, workplace logs maintained in response to OSHA regulations may serve a useful purpose with respect to injuries. As a result, the existence of the system provides an internal stimulus to the employer to focus preventive efforts on causes of occupational disease and injury.

Although underreporting clearly limits the utility of data generated by employers, the data should serve a useful surveillance role, particularly in surveillance of acute injuries,[4] and as a stimulus for improving the health and safety of the workplace.

Conclusion

In 1983, a congressional committee agreed with Dr. J. Donald Millar, the Director of the National Institute for Occupational Safety and Health, that occupational health surveillance was "seventy years behind communicable disease surveillance."[5] Two years later, another congressional committee concluded that occupational health surveillance was "seventy-two years behind and still counting." Hopefully, as a result of the programs reviewed in this monograph and others not described here, the gap is being closed. In view of its technical complexity and significance for policy development, surveillance for occupational disorders will remain among the most challenging of public health programs.

To maintain the gains of recent years and to achieve new accomplishments, continued cooperation between state and federal agencies is essential. Future efforts must build on past accomplishments. We must learn from our failures and be encouraged by our successes. In view of its role in identifying the successes and failures of prevention efforts, surveillance is central to occupational health practice. In occupational health, a commitment to improving surveillance is a commitment to improving the heath and safety of workers.

REFERENCES

1. Baker EL, Melius JM, Millar JD: Surveillance of occupational illness and injury in the United States: current perspectives and future directions. J

Public Health Policy, 1988; 9:198–221.
2. Medical surveillance programs for employees. Federal Register, September 27, 1988; 53(No. 187):37595–37598.
3. National Institute for Occupational Safety and Health: Response to OSHA, Advanced Notice of Proposed Rulemaking on Generic Standard for Medical Surveillance Programs for Employees, December 1988.
4. National Academy of Sciences: Counting Illness and Injury in the Workplace. Washington, DC: National Academy Press, 1987.
5. Occupational Illness Data Collection: Fragmented, Unreliable, and 70 Years Behind Communicable Disease Surveillance. 60th Report by the Committee on Government Operations, October 5, 1984. House Report 98-1142. Washington, DC: Govt Printing Office, 1984.

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