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NIOSH

Occupational Disease, Injury and Hazard Surveillance Activities FY91

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease and Prevention
National Institute for Occupational Safety and Health

NIOSH
Occupational Disease, Injury and Hazard Surveillance Activities

FY91

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Cincinnati, Ohio

FEBRUARY 1993

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Stout N: Development o Nationally Standardized Occupation and Industry Coding Software.

Taylor L, Davis L: Occupational Fatality Surveillance in Massachusetts.

Valiante DJ, Bost P, Stanbury M: Private Industry Compliance with New Jersey's Silicosis Surveillance Program.

ACKNOWLEDGEMENTS

This report was prepared by the members of the NIOSH Surveillance Coordinating Committee (see **Introduction**). The effort was coordinated by Dr. Diana Ordin, Deputy Associate Director for Surveillance, Division of Surveillance, Hazard Evaluation, and Field Studies (DSHEFS), who compiled and edited the report. Credit for the surveillance activities described in this report belongs to the project officers (whose names appear with their project descriptions) and their supervisors. Linda Plybon of DSHEFS prepared the manuscript, and Shirley Carr of the Division of Standards Development and Technology Transfer provided invaluable editorial assistance.

INTRODUCTION

> *Surveillance is the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link of the surveillance chain is the application of these data to prevention and control. A surveillance system includes a functional capacity for data collection, analysis and dissemination linked to public health programs.*
>
> Centers for Disease Control[1]

Surveillance is the eyes and ears of public health. It tells us what our problems are, how big they are, where the solutions should be directed, and how well (or poorly) our solutions have worked.

We all recognize the critical role of such basic public health information in battling the major communicable diseases of our day, such as AIDS and tuberculosis. Occupational health is no different. In order to protect the American worker from injuries and illness in the workplace, we need information on the whereabouts, behavior, and strength of the enemy. What injuries and illnesses are occurring? Where are they occurring? Which workers are affected? What are the risk factors for their occurrence? Have our attempted interventions been effective?

In 1986, a Congressional committee agreed with NIOSH Director Dr. J. Donald Millar that occupational health surveillance was more than 70 years behind communicable disease surveillance[2]. Since that time, considerable progress has been made. There is now a surveillance system to identify all fatal occupational injuries in the United States. There is a surveillance program which sends experts into the field to investigate the causes of these deaths so that similar deaths may be prevented in the future. There is a surveillance program gathering data on adult blood lead levels from 20 states -- a program which has received over 17,000 reports per year and has detected ongoing problems of worker overexposure and exposure to family members through take-home lead. There is a program supporting state-based surveillance systems for occupational diseases and injuries such as carpal tunnel syndrome, pesticide poisoning, silicosis, occupational asthma, and work-related burns. There is a program looking at the occupations and industries listed on death certificates to identify new relationships between work and disease.

This NIOSH Surveillance Report for FY91, the first such report by NIOSH, has been compiled by the NIOSH Surveillance Coordinating Committee for two purposes.

First, by consolidating in a single document descriptions of all NIOSH surveillance activities, as well as reprints of publications resulting from those activities, we hope this report will serve as a convenient

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[1]Centers for Disease Control [1988]. *CDC Surveillance Update*. Atlanta, GA: CDC.

[2]Committee on Government Operations, U.S. House of Representatives [1986]. *Occupational Health Hazard Surveillance: 72 Years Behind and Counting*. Washington, DC: U.S. Government Printing Office House Report 99-979.

resource to federal agencies, state and local governments, academic institutions, labor and trade organizations, and others responsible for establishing surveillance programs or using surveillance data.

This report also represents the first step in systematic assessment of current NIOSH surveillance efforts. We have presented current NIOSH surveillance activity in the context of two sets of national priorities for occupational disease and injury prevention -- *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*, published by the Department of Health and Human Services, and the NIOSH List of 10 Leading Work-related Diseases and Injuries in the United States. This initial assessment reveals some obvious gaps in our surveillance efforts. Other surveillance needs are also underscored. These include the need to comprehensively utilize existing data and collect additional data in order to create truly national surveillance systems; the need for coordination and collaboration among federal and state agencies conducting occupational health surveillance or possessing data useful for such surveillance; and the need for periodic evaluation of surveillance activities. We hope to address these issues more substantively in future reports.

From this report, it is evident that the 70-year gap between occupational disease and injury surveillance and communicable disease surveillance described in 1986 has narrowed. But it is also evident that a considerable gap still exists. We fervently hope that future reports will document further progress in bridging this gap, bringing us closer to our ultimate goal of preventing occupational injury and disease throughout the United States.

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PART I

FY91 Surveillance Activities

ANALYSIS OF NATIONAL HEALTH INTERVIEW SURVEY (NHIS) DATA

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This activity involves the analysis of data collected by the National Center for Health Statistics (NCHS) as part of their ongoing National Health Interview Survey (NHIS). NHIS is a continuous national survey, conducted by personal interview, of a sample of about 40,000 households weighted to provide national estimates of demographic and personal characteristics (including employment), illnesses, injuries, impairments, chronic conditions, utilization of health resources, and other information of interest on the civilian non-institutionalized U.S. population. In addition to the "core" survey instrument, which collects similar information over a number of years, each year the NHIS includes a number of supplements which collect information on a one-time basis on a topic of interest. Both core and supplement data have been examined in a number of projects during FY91:

Prevalence of Chronic Diseases and Impairments in Farmers: Core NHIS data from the 1983-1987 surveys were combined to provide a sufficient number of observations to calculate the prevalence rate of selected conditions in currently-employed white male farm owner/operators and compare it to the rate in the currently-employed white male population as a whole. Self-reported prevalence rates were calculated for the following conditions and impairments: cardiovascular and respiratory conditions, arthritis, skin cancer, hearing loss, amputations, and orthopedic impairments. All were elevated in farmers after age-adjustment.

Analysis of the 1988 Occupational Health Supplement to the NHIS: This Supplement, which was sponsored by NIOSH, collected information on the 12-month self-reported incidence of work-related injuries, and prevalence of hand and wrist discomfort, back pain, exposure to repetitive motions, dermatologic exposures and conditions, eye/nose/throat irritation, and other selected conditions. Current and longest occupation and industry of employment were also collected for all those employed within the last year. The data were received in April 1991 from NCHS and work was begun on an overview paper and in-depth papers on injury and hand/wrist discomfort.

Analysis of the 1985 Supplement on Alcohol Use: Data from this supplement were examined to calculate the prevalence of alcohol use by current occupation and industry. Data from the NIOSH National Occupation Exposure Survey (NOES) were used to identify which of these occupation and industry groups are at high risk of exposure to chemicals that interact with alcohol.

Publications in FY 91: None

MORTALITY SURVEILLANCE OF OCCUPATION AND INDUSTRY

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The Mortality Surveillance of Occupation and Industry project was initiated in FY81 to develop a national occupational mortality surveillance system based on coded information from death certificates. Death certificates are collected and coded by the individual state health departments. This project supports the standardized coding of the occupation and industry information from the certificates.

The Mortality Surveillance project is a collaborative effort by NIOSH, the National Center for Health Statistics (NCHS), the National Cancer Institute (NCI) and several state health departments. NCHS and NIOSH provide coding courses based on the Bureau of the Census classification system as well as other technical support for state health departments. For data year 1991, 33 state health departments and the District of Columbia were routinely coding occupation and industry from the death certificate. In FY91, 18 states (Colorado, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Rhode Island, South Carolina, Utah, Vermont, West Virginia, and Wisconsin) received reimbursement for the coded data. Three additional state health departments (Ohio, Oklahoma, and Washington) provided the data without charge. Four coding courses were held in FY91. Sixteen representatives from nine states attended the basic training courses, and nineteen persons from fourteen states attended the advanced courses. The coded data are collected and edited by NCHS and included on the annual Public Use Multiple Cause of Death computer tape.

NIOSH has done several analyses of the data for surveillance purposes. The standard analysis used for the data is an age-adjusted, race- and sex-specific, proportionate mortality ratio (PMR) analysis. The primary uses of the data have been to describe the mortality profile for selected occupations and industries and to suggest hypotheses about the associations of disease with occupation. A report describing the results of an analysis of 1984 through 1988 data from 23 states will be published as an NCHS Vital and Health Statistics Report.

Several additional FY 1991 analyses of the data for 23 states for 1979-1987 are described below:

Restaurant Workers: The purpose of this study was to identify preventable diseases for which restaurant workers have elevated risks. Sex-and race-specific PMR analyses included 25,005 decedents aged 15 to 64 whose usual job was reported in the restaurant industry. Strong effects of lifestyle are seen in this industry. Alcoholism and chronic liver disease and cirrhosis PMRs were elevated more than 50% for white men who were bartenders, waiters, or cooks, white women bartenders and waitresses, and black waiters and waitresses. High PMRs for smoking-related diseases were seen for white women bartenders (lung cancer) and white waitresses (lung and bladder cancer, chronic obstructive pulmonary disease). Black and white cooks of both genders had significantly elevated PMRs for diabetes mellitus, which may
be related to the easy access to high caloric foods. The PMRs for human immunodeficiency virus infection were highly elevated for black and white waiters, as well as bartenders and cooks. It is evident that restaurant workers experience a high proportion of preventable deaths. (Contact: Carol A. Burnett, (513) 841-4315).

Farmers: As part of the Farm Family Health and Hazard Surveillance and the Migrant Farm Workers projects, proportionate mortality analyses were conducted for the workers employed in occupations and industries related to agriculture, stratified by race and sex. For white males, as compared to the entire employed population, both farmers and farm workers had a higher proportion of deaths due to poisonings and tuberculosis. Farmers also had excessive proportionate mortality due to leukemia and acute myocardial infarctions, while farm workers had excesses in deaths due to alcoholism and chronic obstructive pulmonary disease. Analyses are underway for females and non-whites. (Contact: Lorraine Cameron, (513) 841-4212).

Preventable Mortality for Nonoccupational Diseases: PMRs for preventable causes of death from nonoccupational diseases were calculated according to occupational group in order to assess the value of PMRs for occupational targeting of prevention services and health promotion activities. PMRs were calculated for deaths attributed to preventable disease, including ischemic heart disease, cerebrovascular disease, influenza, cirrhosis, chronic obstructive pulmonary disease, hepatitis B, diabetes, and neoplasia of the lung, cervix, and breast. Although at present occupation is not considered when targeting prevention for these diseases, the results of this evaluation suggest that such targeting may increase the effectiveness of prevention. (Contact: Carol Burnett, (513) 841-4315)

Occupational Mortality Analysis for Black Males 1979-1987: The purpose of this activity was to determine occupations associated with excess proportionate mortality among black men. PMRs were calculated for the seven leading causes of excess death among the U.S. adult black population: cancer, cardiovascular disease, cirrhosis, chemical dependency, diabetes and homicides/accidents. The two occupations with the highest proportion of excess cancer deaths were health aides and supervisors in production occupations. Excess deaths from heart disease and cirrhosis were in excess in pressing machine operators and laborers and cooks (excluding short order). Homicides and accidents were in excess for timber and logging occupations and guards. These data highlight occupations associated with increased proportionate mortality among black males and suggest workplaces where disease prevention and health prevention activities may be most useful.

A case control study was undertaken to further explore some of the occupational associations revealed in the PMR analysis. Age-adjusted odds ratios were calculated for black males who died of cirrhosis, the third leading cause of death. Our results showed increased risk of cirrhosis death among laborers, pressing machine operators, and automotive (garage and service station) workers, as was found in the PMR analysis. (Contact: Janie L. Gittleman, (513) 841-4215, or Carol Burnett, (513) 841-4315)

Occupational Mortality Surveillance Validation: An evaluation of the utility of occupational mortality data to suggest hypotheses about possible work-related diseases was completed in FY91. Although occupational mortality data have been used successfully for surveillance by Great Britain and the state of Washington, the use of these data for identifying leads for studies of occupational disease has never been formally validated. Because of the nature of death certificate data and the lack of information on possible confounding factors, especially smoking, the ability of the data to identify occupational disease has been questioned. Two studies were conducted as part of this evaluation:

A Bladder Cancer Comparison Study: This study examined the utility of the death certificate data by comparing the ability of the data to identify occupations with known or suspected associations with bladder cancer with the results from a population-based case-control study. Death certificate data for white males

from 23 states for 1979-1987 were analyzed using proportionate mortality ratios. The case-control study used cases identified from cancer registries in 10 areas of the U.S. for 1977-1978 and population-based controls. Relative risks, adjusted for smoking, were calculated. Results of the two analyses were compared for 21 *a priori* suspect occupations. The death certificate study identified eight of 15 occupations identified by the case-control study as having a positive association. Five of the *a priori* selected categories were not identified by either study, for an overall agreement of 62 percent. Despite the limitations of death certificate data and the dissimilarities of the two sets of data, the death certificate analysis identified over half of the associations identified by the case-control study. (Contact: Carol A. Burnett, (513) 841-4315)

Uses of Occupational Data on Death Certificates: A Review: To evaluate the utility of occupational mortality surveillance based on PMR analysis of death certificate data, we reviewed epidemiologic studies with positive findings published 1970-1990 that cited associations from analyses of provincial, state, or national occupation-coded mortality data. Our review showed that 36 of the positive findings had been previously identified by occupation-coded mortality data from Washington State, the United States, Canada, Europe, or Great Britain. The temporal (but not causal) relationship of the PMR associations and the epidemiologic studies suggested that associations from occupation-coded death certificates, despite limitations, have value and validity for generating hypotheses and suggesting areas for epidemiologic research. (Contact: Cynthia F. Robinson, (513) 841-4217)

Comparative Occupational Mortality Analysis: Occupational mortality data from three countries (U.S., British Columbia, and Great Britain) were obtained to compare and contrast results. Review and interpretation of the data will permit us to formulate hypotheses about associations between occupation and cause of death. Preliminary results for 29 occupations for extent of agreement for all causes of death showed overall agreement among the data sets of 74% to 94%. Data from the entire database are being reviewed for the purpose of targeting selected occupations that show potential high risk across the three comparison countries. (Contact: Joyce A. Salg, (513) 841-4209)

Publications in FY91:

Burnett C, Gittleman J, Lalich N [1991]. Preventable mortality in the restaurant industry (Abstract). *Am J Epidemiol* 134:743.

Robinson C, Lalich N, Burnett C, Sestito J, Frazier T, Fine L [1991]. Electromagnetic field exposure and leukemia mortality in the United States. *J Occup Med* 33:160-162.

SENTINEL EVENT NOTIFICATION SYSTEMS FOR OCCUPATIONAL RISKS (SENSOR)

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SENSOR is a five-year program of cooperative agreements with state and territorial health departments to pilot case-based surveillance and prevention-oriented follow-up activities for selected occupational health conditions. Ten states (California, Colorado, Massachusetts, Michigan, New Jersey, New York, Ohio, Oregon, Texas, and Wisconsin) have received SENSOR funding for surveillance of one or more of the following conditions: elevated blood lead, carpal tunnel syndrome, pesticide poisoning, occupational lung diseases (silicosis and other pneumoconioses, occupational asthma, and hypersensitivity pneumonitis), and work-related burns. Several states also conducted short-term evaluations of work-related bloodborne disease in health care workers and emergency responders.

Case ascertainment methods, which vary by state and by target condition, have included case reporting by physicians, hospitals, and laboratories; hospital discharge data; and death certificates. Case follow-up and intervention strategies, which also vary by state and by target condition, have included worksite investigations with screening of co-workers; physician, worker, and employer education efforts; referral to enforcement agencies; and the use of hazard surveillance strategies to target facilities similar to those identified through case reports. NIOSH-recommended surveillance case definitions have been published in MMWR for silicosis [1990] 39:436), asthma [1990] 39:121), and carpal tunnel syndrome [1989] 38:487).

The primary objective of these surveillance activities is to identify cases of occupational disease and injury and, through follow-up of these cases, to identify workplaces and industries where prevention-oriented interventions may be targeted. Further study is needed to determine the potential utility of the SENSOR data in estimating incidence and/or prevalence rates of the target conditions.

The original SENSOR cooperative agreements are now in their final year and applications have been solicited for a second five-year funding cycle to begin in FY92. Approximately $1.3 million will be available to fund cooperative agreements for three types of state-based surveillance activities:

1. SENSOR Experimentation: To support the design of new state-based surveillance systems, addressing new target conditions and/or surveillance methodologies not currently funded by SENSOR, as well as current SENSOR experiments whose effectiveness has not yet been determined.

2. SENSOR Field-Testing: To field-test in additional states feasible and effective surveillance approaches developed in SENSOR experimental programs. Surveillance strategies currently ready for field-testing are:

   a. Hospital reporting of hospitalized work-related burns;

   b. Silicosis surveillance utilizing each of three sources of case ascertainment: physician reporting, hospital

discharge data, and death certificates; and

c. Occupational asthma surveillance based on physician reporting.

3. SENSOR Implementation--Blood Lead Surveillance: To encourage universal implementation of surveillance of elevated blood lead in adults based on mandatory laboratory reporting of elevated blood lead levels. This activity is described elsewhere in this report.

In addition to the new SENSOR cooperative agreements, other plans for FY92 include: standardization of data collection and analysis for the SENSOR field-testing conditions, increased publication of SENSOR data in the *MMWR*, facilitation of communication among participating health departments through meetings and an information clearinghouse, and formal general and target-condition-specific evaluations of the SENSOR program.

Publications in FY91:

California Occupational Health Program [1991]. Ergonomics in the Workplace: A Survey of a Santa Clara County-Based Business Association. California Department of Health Services, Berkeley, Report No. SR90-004.

Feldstein A, Heumann M, Barnett M [1991]. Fumigant intoxication during transport of grain by railroad. *Jl Occ Med* 33:64-5.

Hanrahan LP, Higgins D, Anderson H, Haskins L, Tai S [1991]. Project SENSOR: Wisconsin surveillance of occupational carpal tunnel syndrome. *Wisconsin Med. Jl* February:80-83.

Henry JP, Willis T, Schulze L, Hahn S [1991]. Reporting of Occupational Pesticide Poisonings, Texas Southern High Plains Region, 1989-90. Texas Department of Health, Austin.

Kipen HM, Gelperin K, Tepper A, Stanbury M [1991]. Acute occupational respiratory diseases in hospital discharge data. *Am J Ind Med* 19:637-642.

Massachusetts Department of Health [1991]. Asbestos-Related Lung Disease in Massachusetts Workers. Massachusetts Department of Health, Boston.

Massachusetts Department of Public Health [1990]. Hepatitis B in Massachusetts Health Care Workers 1984-1989. Massachusetts Department of Health, Boston.

Matte TD, Hoffman RE, Rosenman KD, Stanbury M [1990]. Surveillance of occupational asthma under the SENSOR model. *Chest Supplement* 98:173S-178S.

Michigan State Medical Society [1991]. Occupational disease in Michigan. *Medical Inquirer* 4.

Rosenman KD, Trimbath L, Stanbury M [1990]. Surveillance of occupational lung disease: Comparison of hospital discharge data to physician reporting. *Am J Public Health* 80:1257-8.

Windau J, Rosenman K, Anderson H, Hanrahan M, Rudolph L, Stanbury M, Stark A [1991]. The identification of occupational lung disease from hospital discharge data. *Jl Occ Med* 33:1060-1066.

Newsletters containing SENSOR-related material were published by the health departments of California, Colorado, Massachusetts, Michigan, New Jersey, Ohio, Oregon, Texas, and Wisconsin.

DEVELOPMENT OF RESPIRATORY DISEASE SURVEILLANCE SYSTEMS

Division of Respiratory Disease Studies
Epidemiological Investigations Branch
Surveillance Section

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This project focuses on the development of occupational respiratory disease surveillance systems on a national basis. These systems incorporate data collection, data analysis and information dissemination. Databases previously unused for occupational respiratory disease surveillance are explored for potential use in routine surveillance reporting. Previously analyzed databases will continue to be updated annually.

Mortality Surveillance: Multiple-cause-of-death data tapes prepared by the National Center for Health Statistics (NCHS) are analyzed. All deaths reported annually in the United States are coded by NCHS. Since 1968 all conditions listed on the death certificate have been coded according to appropriate International Classification of Disease (ICD) codes. Other data coded for each decedent and used in analyses include sex, race, age at death, county and state of residence. Since 1985 usual occupation and industry have been coded in approximately 20 states annually.

Temporal and geographic trends: Temporal and geographic patterns in deaths with coal workers' pneumoconiosis (CWP), silicosis, asbestosis, byssinosis, hypersensitivity pneumonitis, and mesotheliomas from 1968-1987 were developed. Records were identified by mention on the death certificates of specific ICD-8 and ICD-9 codes related to the disease of interest. Some county level analyses were initiated. Premature mortality and standardized rates over time were computed, standardizing to US population statistics. Limitations of these data are the identification of appropriate denominators for rate development and the lack of industry/occupation coding for all states. Analysis of additional conditions, more detailed geographic and occupational analyses are planned for 1992.

Morbidity Surveillance: Data from national databases and NIOSH programs are sources of morbidity data for occupational respiratory disease surveillance systems. In FY92 additional analyses are planned on the NCHS National Health Interview Survey (NHIS) and on a special subset of Medicare Provider and Review (MEDPAR) records.

Hospital Discharge Data: Numbers of hospital discharges with specified respiratory diseases, from the NCHS National Hospital Discharge Survey (NHDS) are summarized from 1970-1987. Diseases are identified by ICD codes. Limitations of these data are that they are based on a sample of hospital records, are not available by state, and represent number of discharges rather than cases. The number of hospital discharges in Medicare recipients, based on ICD codes for selected lung conditions from the MEDPAR file, are summarized by state for 1984-1989. These data provide a 100% count of cases. Limitations are that discharges rather than cases are reported. For hospital discharge data, appropriate denominators are not yet developed.

Trends in Coal Workers' Pneumoconiosis (CWP) Morbidity: Trends in CWP prevalence for coal miners participating in the NIOSH-administered Coal Workers' X-ray Surveillance Program (CWXSP) are developed for 1970-1989. (See elsewhere in this report for detailed CWXSP program description.) These trends are based on results of chest radiographs of coal miners working at underground coal mines. Coal miner participation rates have decreased since 1970, possibly introducing selection bias. Data should be used with caution when relating results to the entire coal mine work force. Efforts to increase voluntary participation and to obtain more specific data on coal miner demographics are currently underway.

Publications in FY91:

NIOSH [1991]. Work-Related Lung Disease Surveillance Report. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 91-113.

NATIONAL COAL WORKERS AUTOPSY STUDY (NCWAS)

Division of Respiratory Disease Studies
Examination Processing Branch
X-Ray Receiving Center Section

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The project is mandated by the Federal Mine Safety and Health Act of 1969 and Amendments Act of 1977. This legislation authorizes an autopsy on deceased coal miners at the request of the miners' families and provides for payment for such services. The activity serves both service and research functions, providing families with autopsy results for use in support of compensation claims, and providing a data base complete with lung tissues, microscopic slides, medical reports, and work histories for use in research of coal workers' pneumoconiosis and other respiratory diseases in miners.

The NCWAS has been an ongoing activity since 1971. As of 10/91 there were in excess of 5,800 cases submitted to this project. During the first 10 years following implementation of the study, cases were received at a rate of 300 to 400 per year. During the last decade, numbers have decreased yearly and have stabilized at approximately 200/year.

During the past two decades, materials from the NCWAS have yielded numerous publications and provided much insight into the onset and progression of coal workers' pneumoconiosis.

Publications in FY91:

Dalal NS, Jafari B, Petersen M, Green FHY, Vallyathan V [1991]. Presence of stable coal radicals in autopsied coal miners' lungs and its possible correlation to coal workers' pneumoconiosis. *Arch Environ Health* 46(6):366-372.

NATIONAL COAL WORKERS X-RAY SURVEILLANCE PROGRAM (NCWXSP)

Division of Respiratory Disease Research
Examination Processing Branch
X-Ray Receiving Center Section

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Mandated by the Federal Mine Safety and Health Act of 1969 and 1977, this activity provides for periodic chest x-ray examinations for all working underground coal miners, at the expense of the employer, for the purpose of detecting coal workers' pneumoconiosis (CWP). Any miner found to have developed CWP must be offered an opportunity to work in a low-dust area of the mine with no loss of pay. Data gathered from participating miners contributes to assessment of the effectiveness of recommended dust standards for the mining industry.

Since implementation of the Program following the 1969 Act, more than 348,000 chest x-rays on over 223,000 miners have been submitted to the program. Over 9,000 of these miners have been given the option to work in less dusty environments.

Early in the Program, high employment in the mining industry and heightened interest and awareness of "black lung" led to widespread participation in the program. More recently, factors such as limited employment in the mining industry and concerns for job security and confidentiality have adversely impacted participation. These factors, as well as limited data on work history, tenure, and type of mining operation, represent limitations for the use of these data to evaluate trends in incidence and prevalence of coal workers' pneumoconiosis or the effectiveness of mining industry dust standards.

Program modifications are in place to overcome these limitations by increasing miner participation and obtaining additional data on mining experience and job classification.

Publications in FY91: None

FATALITY ASSESSMENT AND CONTROL EVALUATION (FACE)

Division of Safety Research
Surveillance and Field Investigations Branch
Trauma Investigations Section

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The Fatality Assessment and Control Evaluation (FACE) Project has two components. The first is an in-house program in which state agencies and associations in eleven participating states notify the Division of Safety Research (DSR) of traumatic occupational fatalities resulting from falls, electrocutions, and confined spaces related incidents. DSR safety personnel conduct epidemiologic investigations of these incidents.

The second component is a five-year program of cooperative agreements with nine state health departments (Alaska, California, Colorado, Massachusetts, Minnesota, Missouri, New Jersey, Wisconsin, and Wyoming) to build state capacity for conducting traumatic occupational fatality surveillance, investigation, and intervention activities through the adoption of the NIOSH FACE Program Model.

The state FACE programs include multiple-source surveillance systems for identifying all traumatic occupational fatality events occurring within the state. Fatality investigations are also conducted for selected causes of death to identify risk and causal factors and recommend successful intervention strategies. Data collected from initial surveillance and subsequent investigations are transmitted to DSR for epidemiologic analyses. States use these data to prioritize and develop traumatic occupational injury research and prevention programs.

Future plans include expansion of the FACE Project into all states and territories and investigation of all fatal occupational injuries nationwide.

Publications in FY91:

Casini VJ, Collins JW, Myers JR [1991]. Preventing lineworker fatalities. *Public Power*, July-August:20-26.

Manwaring JC, Conroy C [1991]. Confined space fatalities--surveillance and prevention. *Operations Forum* 8(7):10-13.

NIOSH [1991]. *Preventing Electrocutions During Work With Scaffolds Near Overhead Power Lines*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 91-110.

Thirty-three FACE investigation reports for traumatic occupational fatalities in nine states (including 12 electrical-related, seven confined space-related, and 14 fall-related) are available from the Division of Safety Research.

NATIONAL TRAUMATIC OCCUPATIONAL FATALITIES (NTOF)

Division of Safety Research
Surveillance and Field Investigations Branch
Injury Surveillance Section

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The National Traumatic Occupational Fatalities (NTOF) surveillance system is a death certificate-based census of all occupational injury deaths occurring in the U.S. The criteria provided to the states for the submission of certificates are: 1) 16 years of age or older; 2) an external cause of death (ICD-9, E800-E999); and 3) a positive response to the "injury at work?" item on the death certificate.

Data collection is complete for deaths that occurred in 1980 through 1988. This is an ongoing data collection effort, and data for 1989 should be complete by June 1992. The data are used to describe the nature and magnitude of the occupational injury problem in the U.S., to generate hypotheses for further epidemiologic research, and to set research and prevention priorities. The NTOF database includes variables useful for describing the characteristics of victims as well as injury circumstances, including a narrative "injury description" and both narrative and coded entries for industry, occupation, and cause of death.

NTOF underenumerates fatal occupational injuries because no standardized definition or guidelines are currently in use for the completion of the "injury at work?" item on the death certificate. Such guidelines are currently being developed for national implementation in 1993. State-based studies indicate that death certificates identify a greater proportion of occupational trauma fatalities than other sources, capturing 67% to 90% of all fatal work injuries. Studies also indicate that motor vehicle crashes and homicides are the causes of death most apt to be missed in death certificate surveillance of occupational injuries.

Publications in FY91:

Bell CA [1991]. Female homicides in United States workplaces, 1980-1985. *Am J Public Health* 81:729-732.

Etherton JR, Myers JR, Jensen RC, Russell JC, Braddee RW [1991]. Agricultural machine-related deaths. *Am J Public Health* 81:766-768.

Stout NA, Bell CA [1991]. Effectiveness of source documents for identifying fatal occupational injuries: A Synthesis of Studies. *Am J Public Health* 81:725-728.

AN ASSESSMENT OF THE EFFECTIVENESS OF OSHA'S LEAD STANDARD

Division of Surveillance, Hazard Evaluations and Field Studies
Surveillance Branch
Illness Effects Section

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The purpose of this project is to survey companies in Ohio which use lead or lead-containing compounds. The survey is a collaborative effort with Ohio Health Department and the Ohio Bureau of Workers' Compensation. A sample of companies will be surveyed to determine: (1) the types of lead-using companies doing environmental and/or biological monitoring, (2) the results of such monitoring, (3) the reasons why lead-using companies are not doing monitoring, (4) the exposure levels in those lead-using companies not doing monitoring, and, (5) the level of awareness among lead-using companies of the monitoring requirements of the OSHA Lead Standard. The survey results will be used to target specific industrial sectors for intervention and research activities.

The survey will consist of two phases. The first phase is a self-administered questionnaire mailed to a stratified random sample of approximately 2,000 facilities in industries (identified by SIC code) with documented evidence of lead exposure. The second phase is a field phase which will consist of follow-up investigations of a subsample of about 200 facilities from the questionnaire phase. The follow-up investigations may involve a telephone inquiry, a walkthrough survey, and/or air monitoring. The purpose of the field phase is to verify information collected in the questionnaire, to collect additional information about work areas where lead is used, to determine air lead levels in companies not currently monitoring for lead, and to obtain information about non-respondents to the mail questionnaire.

The initial survey protocol was submitted for OMB approval and was disapproved in FY 1991. The OMB decision is being appealed. A supporting document was written for the appeal.

Publications in FY91: None

SURVEILLANCE FOR OCCUPATIONAL LEAD EXPOSURE

Division of Surveillance, Hazard Evaluations and Field Studies
Surveillance Branch
Medical Section

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This project assists states in establishing surveillance programs for laboratory reports of elevated blood lead levels in adults and has initiated efforts to routinely collect and disseminate these data from states. Eighteen states (Alabama, California, Colorado, Connecticut, Illinois, Iowa, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, South Carolina, Texas, Utah, Wisconsin) conducted adult blood lead surveillance in 1991 and received nearly 19,000 reports of blood lead levels in excess of 25 ug/cl. Eight of these 18 states were supported by cooperative agreements with NIOSH, including five (AL, CT, MA, MI, OR) funded by the CDC Prevention Research and Development Program and three (NY, TX, WI) by the NIOSH Sentinel Event Notification System for Occupational Risk (SENSOR).

State blood lead surveillance activities have in common: 1) a regulation specifying a "reporting level"; 2) requirements that laboratories as well as health care providers report; 3) means for gathering further essential information about reported cases; and 4) a linkage to follow-up activities ranging from education efforts to field investigations. Examples of state-initiated field investigations conducted in 1991 included: lead poisoning among workers in a battery reclamation facility and take-home lead exposures to their children; excessive lead exposures from lead chromate among plastics workers; lead poisoning in bridge reconstruction workers; and lead burning as a source of lead exposure.

NIOSH blood lead surveillance activities , in conjunction with researchers from DPSE have served to document the size of the lead exposure problem in the workplace, assist public health agencies in focusing on industries where the control of lead exposure remains a problem, guide engineers in the design of technologies to control lead in the workplace, and disseminate information through educational efforts, publication of reports and articles, and presentations at meetings.

Publications in FY91:

NIOSH [1991]. Control of excessive lead exposure in radiator repair workers. *MMWR* 40:139-141.

NIOSH [1991]. Lead poisoning among bricklayers - Washington state.
MMWR 40:169-171.

NIOSH [1991]. *NIOSH Alert: Request for Assistance in Preventing Lead Poisoning in Construction Workers*. Cincinnati, Ohio: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 91-116.

OCCUPATIONAL PSYCHOLOGICAL DISORDER SURVEILLANCE

Division of Surveillance, Hazard Evaluations and Field Studies
Surveillance Branch
Illness Effects Section

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The purpose of this project is to review available resources and make recommendations for developing methods for surveillance of work-related psychological disorders.

In FY91 a draft of a planning document for the surveillance of psychological disorders was completed. This report identified the need for baseline data regarding the frequency and distribution of mental disorders and employment stressors in the workplace. A conceptual framework for the consideration of surveillance options was developed and possible surveillance approaches were reviewed. Short-term activities and long-term approaches to building a comprehensive program for the surveillance of work-related psychologic disorders were recommended. The report is being revised and finalized in collaboration with co-authors from the Division of Biomedical and Behavioral Sciences.

Publications in FY 91: None

FARM FAMILY HEALTH AND HAZARD SURVEILLANCE (FFHHS)

Division of Surveillance, Hazard Evaluations and Field Studies
Surveillance Branch
Illness Effects and Hazard Sections

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The purpose of this project is to obtain population-based prevalence and incidence data for farmers and farm families on disease, injury, workplace exposures, conditions of exposure, work practices, and access to health care, according to commodity, size of farm, demographic characteristics, non-farm employment, and other risk factors. Specific health conditions or diseases being surveyed include: injuries, musculoskeletal conditions, acute and chronic respiratory conditions, hearing loss, dermatologic conditions, mental health, neurotoxic effects, and cancer. Specific workplace exposures being surveyed include noise, pesticides, dusts, gases, vibration, unguarded equipment, confined spaces, animal handling and medicinals. Specific work practices to be evaluated include use of respirators, protective clothing, and application of farm chemicals, including pesticides. The project is designed to support surveys in six states (California, Colorado, Iowa, Kentucky, New York, and Ohio) under cooperative agreements with NIOSH.

In FY91, meetings were held in Cincinnati with investigators from each of the six survey states to discuss plans for the surveys and approaches to assure comparability among the surveys. NIOSH staff collaborated with the survey investigators on the design of questionnaires, survey protocols, and questionnaire pretesting. NIOSH staff conducted site visits of each state survey program. Supporting Statements were prepared for submission to the Office of Management and Budget (OMB) to obtain Federal Reports Act clearance for the surveys.

Publications in FY91: None

Related project activities include:

FFHHS Survey Instrument Design: Health History and Examination (Contact: Lorraine Cameron, (513) 841-4212). The goal of this activity is to develop standardized survey instruments for the FFHHS to collect self-reported 12-month incidence of injuries and prevalence of musculoskeletal, respiratory, dermatologic, audiometric, neurotoxic and stress-related symptoms; cancer awareness; and access to health care and insurance. These prevalence rates will be compared to national rates from the National Center for Health Statistics (NCHS) National Health Interview Survey (NHIS) and other standardized surveys which were used as the models for the NIOSH draft interview instrument modules. All the investigators have used the NIOSH draft instrument modules to develop their interview instruments and have produced at least one draft for NIOSH review. Investigators in Ohio and California performed some informal pretesting of their instruments.

This activity has also produced standardized audiometric and spirometric procedures for the FFHHS medical examinations. The procedures were developed in collaboration with the NIOSH Division of Respiratory Disease Studies and the Division of Biomedical and Behavioral Sciences. The procedures are based on those used in the NCHS Health and Nutritional Examination Survey (HANESII & III) and the data collected should be comparable to HANES II & III data on the general U.S. population.

To aid in planning for the surveys, analyses were completed on disease characteristics of farmers and farm workers using pooled NHIS and death certificate data. Workers' compensation data from the Bureau of Labor Statistics Supplementary Data System were also used to examine causes of morbidity in agricultural workers; this work is still underway.

Publications in FY91: None

FFHHS Survey Instrument Design: Hazard Assessment and Observational Walkthrough (Contact: Joseph Seta, (513) 841-4491). The primary goal of this project is to develop exposure assessment questionnaires, observational walkthrough protocols, and standardized data collection forms to be used by state health departments and land grant universities participating in the FFHHS cooperative agreement program. These protocols and standardized forms will address such areas as types of agents, frequency and timing of use of agents, mechanisms of application, perception of health or safety hazard, use of control measures, and ergonomic, physical, chemical, biological, and safety hazard exposures in the agricultural sector. A subset of farms will be visited to validate information derived from the questionnaire.

Publications in FY91: None

FFHHS Surveyor Training (Contact: David Pedersen, (513) 841-4491). This project provides training for conducting hazard assessments and observational walkthrough surveys for the FFHHS. The training is provided at the request of any of the states awarded FFHHS cooperative agreements. The curriculum consists of 18 videotape lectures and additional handout material and closely parallels the survey protocols developed for the National Occupational Exposure Survey (NOES). The training course materials are expected to be available to the public in FY93.

Publications in FY91: None

FFHHS On-Site Evaluation: Quantitative Industrial Hygiene Sampling (Contact: Herbert Venable, (513) 841-4491)

This project is charged with providing industrial hygiene sampling and analytical protocols for the collection of exposure data on noise, dust, gases, and pesticides for the FFHHS. In addition, assistance will be provided in the development of new sampling and analytical protocols for the collection of industrial hygiene samples and biological monitoring. Emphasis will be placed on the use of NIOSH approved/developed methods to facilitate the comparison of data among surveys. DPSE is working with DSHEFS on this project.

Publications in FY91: None

FFHHS Spriometry Training and Support (Contact: John L. Hankinson, (304) 291-4755). This project provides support to the spirometry component of FFHHS. Pulmonary function equipment will be maintained, training provided, and quality control performed, to insure a uniform approach to data collection. Pulmonary function data will be processed by NIOSH and reviewed for quality. Copies of these data will be generated and provided to appropriate participating parties. Follow-up quality control activities, including field monitoring of technicians, will be performed.

Publications in FY91: None

HEALTH AND HAZARD SURVEILLANCE OF MIGRANT FARM WORKERS

Division of Surveillance, Hazard Evaluations and Field Studies
Surveillance Branch
Illness Effects Section

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The goals of this project are: 1) to describe the current state of knowledge of the occupational hazards and health of migrant and seasonal farm workers (MSFW); 2) to identify existing and potential mechanisms for implementing and conducting health and hazard surveillance of MSFW; 3) to analyze the feasibility of using these mechanisms to build an occupational health surveillance system for MSFW; and 4) to make recommendations regarding further research on MSFW occupational health.

Contact has been made with many groups and experts who are working with MSFW to find out what data sources are available for evaluating MSFW occupational health. Sources of information will be compiled into a compendium which can be used as a reference.

As part of our evaluation of in-house data sets for MSFW surveillance, proportionate mortality analyses were conducted for the workers employed in occupations and industries related to agriculture (see **Mortality Surveillance of Occupation and Industry**). Workers' compensation data from the Bureau of Labor Statistics Supplementary Data System were used to examine causes of morbidity in agricultural workers. This work is still underway.

Publications in FY 91: None

OCCUPATIONAL HEALTH NURSES IN AGRICULTURAL COMMUNITIES (OHNAC)

Division of Surveillance; Hazard Evaluations and Field Studies
Surveillance Branch
Medical Section

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The Occupational Health Nurses in Agricultural Communities (OHNAC) project is a component of the NIOSH Agricultural Initiative which was funded in FY90. Ten cooperative agreements between NIOSH and state health departments (California, Georgia, Iowa, Kentucky, Maine, Minnesota, New York, North Carolina, North Dakota, and Ohio) fund the placement of public health/occupational health nurses in agricultural communities. Local recruiting of nurses with farm backgrounds and interests in agriculture has enhanced their ability to become a part of the communities they serve; to establish effective disease and injury reporting systems based on the cooperation of health care providers, hospitals and other potential sources; and to follow up their information-gathering activities with public health interventions (usually education or the recruitment of other resources such as cooperative extension service, NIOSH, etc.)

To date, 30 nurses have been placed in agricultural communities and have developed working coalitions with community leaders and existing agricultural health and safety groups. Findings and areas of focus have included pesticide poisonings, power take-off (PTO) injuries, occupational respiratory diseases, tetanus, daycare needs, spouse abuse, and depression.

Though techniques and limitations vary from state to state, all OHNAC projects involve case surveillance and follow-up of sentinel events. Consequently, those projects which have legal or administrative obstacles to follow-back the case reports to individuals are experiencing the most difficulty.

In June 1991 NIOSH provided project nurses with week-long workshops in epidemiologic principles and agricultural health and safety issues.

Related Project activities include:

OHNAC Spirometry Training and Support (Contact: John L. Hankinson, (304) 291-4755). This project provides support to the spirometry component of OHNAC. Pulmonary function equipment will be maintained, training provided, and quality control performed, to insure a uniform approach to data collection. Pulmonary function data will be processed by NIOSH and reviewed for quality. Copies of these data will be generated and provided to appropriate participating parties. Follow-up quality control activities, including field monitoring of technicians, will be performed.

Publications in FY91: None

OCCUPATIONAL RESPIRATORY DISEASE IN AGRICULTURE

Division of Respiratory Disease Studies
Epidemiological Investigations Branch
Surveillance Section

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The purpose of this surveillance study is to generate hypotheses at the state and county levels regarding potential respiratory disease problems in agricultural workers. Decedent information was obtained from the National Center for Health Statistics (NCHS) multiple cause of death data tapes for the years 1985-1988, which contain industry and occupation data for each decedent. Our study population was limited to any deceased worker whose death certificates mentioned a respiratory disease either as the underlying cause of death or as a contributing cause of death. These data are used in calculating premature mortality, disease prevalence, proportionate mortality ratios, and in the comparison of underlying and contributing causes of death. Limitations of this type of mortality surveillance include inaccuracy of death certificate information, lack of good denominator data, inability to control for confounding variables, and absence of data for some states. This project has not been funded for FY 1992 but may be reinstated at a future date.

Publications in FY91: None

CONSTRUCTION TRADES SURVEILLANCE

Division of Surveillance, Hazard Evaluations and Field Studies,
Surveillance Branch
Illness Effects Section

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Under the Construction Trades Surveillance project, mortality studies are conducted using national construction trades unions' computerized death benefit and membership records.

In response to a request for assistance from the Building and Construction Trades Department of the AFL-CIO, a report was prepared by NIOSH and shared with national union officials. One report summarized existing occupational health data for construction trades workers. A feasibility study showed that the construction trade unions' membership records would provide an adequate basis for the initiation of occupational health surveillance and intervention. NIOSH presented the findings from the two reports at several scientific meetings in FY91.

Four proportionate mortality ratio (PMR) studies are currently underway for four national construction trade unions--the United Brotherhood of Carpenters and Joiners of America, the International Brotherhood of Electrical Workers, the International Association of Bridge, Structural and Ornamental Iron Workers, and the Laborers' International Union of North America. The unions, which are actively collaborating in the studies, were selected using a priorities matrix based on FY90 site visits and literature review. Their mortality experience will be compared to the U.S. population and the U.S. blue collar population. The results of the studies will be used to identify causes of death among construction workers for targeting research and intervention. The project lies at the interface between surveillance and etiological research. It challenges researchers to obtain valid exposure information from the unions' records to enable subdivision of membership into useful categories (such as carpenters exposed to wood dust). An additional objective is to assist the unions in conducting their own in-house mortality surveillance, including periodic analyses to assess trends. The estimated completion date of the first PMR study is FY93.

Publications in FY91:

Robinson C, Venable H, Stern F, Burnett C, Sieber K, Sestito J, Frazier T, and Fingerhut M. [1991]. Potential exposures and the occupational mortality of construction workers 1984-86: Filling in the Gaps (Abstract). *Am J Epid* 134:743.

ACCESS TO NATIONAL OCCUPATIONAL HAZARD SURVEY (NOHS), NATIONAL OCCUPATIONAL EXPOSURE SURVEY (NOES), AND JOB/EXPOSURE MATRIX (JEM) DATABASES – PROFILE DEVELOPMENT

Division of Surveillance, Hazard Evaluations and Field Studies
Surveillance Branch
Hazard Section

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Access to National Occupational Hazard Survey (NOHS), National Occupational Exposure Survey (NOES), and Job/Exposure Matrix (JEM) Databases--Profile Development is an ongoing program to provides data from three hazard surveillance databases in response to requests from NIOSH researchers, other federal government agencies, state government, academia, foreign governments, and other private researchers.

NOHS contains data from a 1972-74 survey of a representative sample of all U.S. non-agricultural businesses covered under the Occupational Safety and Health Act of 1970 and employing eight or more employees. The NOES database contains data from a similar survey conducted 1981-83.

The profiles developed under this project provide information on potential exposure to chemical, physical, and biological agents as observed during the conduct of the two national surveys. Data are provided on number of workers potentially exposed, conditions of exposures, use of personal protective equipment, and gender specificity by occupational category and by standard industrial classification. Facility-specific information, such as availability of medical services, health and safety personnel, and air monitoring programs, is also available. The data are widely used within NIOSH to assist researchers in the identification of high-risk occupational groups and for the prioritization of research needs.

The utility of the observational data in the NOHS and the NOES has been enhanced by cross-referencing with other databases, such as the OSHA Integrated Management Information System (IMIS) file, in order to access available quantitative exposure data.

Publications in FY91: None

Related project activities include:

Job/Exposure Matrix (Contact: W. Karl Sieber, (513) 841-4491). The Job/Exposure Matrix (JEM) is a classification system linking occupational titles with potential occupational exposures for use in exposure surveillance. Two versions of the JEM have been developed: one using data collected during the 1972-1974 National Occupational Hazard Survey (NOHS), and one using data collected during the 1981-1983 National Occupational Exposure Survey (NOES). The survey sample in each case was representative of all U.S. non-agricultural businesses covered under the Occupational Safety and Health Act of 1970 and employing eight or more employees. Potential worker exposure to all chemical, physical, or biological agents were recorded during the field survey if certain minimum guidelines for exposure were met. Potential exposure data collected during each survey were cross-classified by industry and occupation of occurrence in the JEM.

The JEM itself is a computerized database that assists the user in determining potential chemical or physical exposures in occupational settings. Documentation and software have been developed to access information contained in the JEM, and the file is available using different industry and occupation coding schemes. The JEM may be used to identify industry and occupation groups where potential exposure to a given agent may occur, or to determine exposure classifications for epidemiological studies. A major advantage of the JEM is that all exposure data are based on field observations. Disadvantages include the possibility of misclassification of exposures within occupations and job titles.

Publications in FY91:

Sieber WK, Sundin DS, Frazier, TM, and Robinson DF [1991]. Development, use, and availability of a job exposure matrix based on national occupational hazard survey data. *Am J Ind Med* 20:163-174 .

Multivariate Analysis of Data Collected in the National Occupational Exposure Survey (NOES) (Contact: W. Karl Sieber, (513) 841-4491). Previous analyses of data collected during the Management Interview Survey of the 1981-1983 National Occupational Exposure Survey (NOES) have included generation of estimates of numbers of employees in facilities with specific operating characteristics, bivariate analyses of data, and comparisons of data between the 1972-1974 National Occupational Hazard Survey (NOHS) and NOES interview surveys. Bivariate analyses have taken the form of cross tabulations to determine odds ratios indicating the strength of association between two operating characteristics. Multivariable methods, including multivariate regression and factor analysis to investigate associations when multiple operating characteristics of the facilities are taken into account, will be developed. Of particular interest are the relationship of occupational safety and health training programs and the presence of safety or industrial hygiene personnel, number of employees, presence of union, years of operation, and presence of monitoring programs.

Publications in FY91:

Pedersen DH, Venable HL, and Sieber WK [1990]. An examination of occupational medicine practices. *J Occup Med* 32(10):1037-1041.

ENVIRONMENTAL HAZARD SURVEILLANCE

Division of Respiratory Disease Studies
Environmental Investigations Branch
Environmental Surveillance Team

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Environmental Hazard Surveillance (EHS) monitors several sources of environmental data pertinent to occupational respiratory diseases and summarizes portions of the data on an annual basis.

EHS analyzes data from: (1) the Occupational Safety and Health Administration (OSHA) Integrated Management Information System (IMIS); (2) the Mine Safety and Health Administration (MSHA) Coal Mine Inspection Data; and (3) the MSHA Metal/Nonmetal Mine Inspection Data. In 1990 those three sources generated approximately 80,000 records, with each record representing a measured exposure level for an agent of health significance.

The OSHA IMIS data cover those states for which OSHA is the enforcement agency for federal occupational safety and health regulations, as well as some states for which a state agency is the enforcer. The specific states covered have varied from year to year, depending on the states' enforcement arrangements and other factors. In 1990, 49 states (all except Vermont), as well as the District of Columbia, Puerto Rico, and the Virgin Islands, were represented in the OSHA IMIS system. All industrial hygiene data gathered by OSHA inspectors in those 52 jurisdictions are included in the IMIS data. The MSHA data for coal mines includes coal mine dust data (including quartz percentages) from federal inspections of coal mines in the U.S. Additionally, the MSHA data for coal mines includes data submitted by the coal mine operators, as required by MSHA regulations. The MSHA data for metal and nonmetal mines includes all industrial hygiene data from federal inspections of non-coal mines. All states, as well as the District of Columbia and Puerto Rico, are covered by the MSHA data.

In developing the annual summary, EHS normally focuses on the following respiratory disease agents: respirable quartz from general industry; respirable quartz from metal and nonmetal mines; respirable quartz from coal mines; coal mine dust from coal mines; cotton dust from general industry; asbestos from all industries. The data are used as an estimate of current trends in occupational exposures to the indicated disease agents.

The data are not necessarily representative of all worksites in the United States and each data source has its own particular biases. In particular, Federal inspectors are often responding to complaints or are seeking out "worst-case" scenarios.

EHS will incorporate data from states which are not currently represented as those data become available.

Publications in FY91: None

NATIONAL OCCUPATIONAL HEALTH SURVEY OF MINING (NOHSM)

Division of Respiratory Disease Studies
Environmental Investigations Branch
Environmental Surveillance Team

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NOHSM is a data set which began as a 5-year survey of all types of mines in the United States. The goal of the NOHSM is to accurately describe, on a continuing basis, the chemical and physical agents which are used or found in U.S. mines. This goal is mandated by the 1977 Federal Mine Safety and Health Amendments Act, Section 101(a)(6)(B).

The NOHSM is presently derived from a series of observational surveys made at a representative sample of U.S. mines during the period of 1984-1989. NIOSH employees personally visited each mine in the sample, spoke with representatives of mine management to obtain responses to a standardized questionnaire, listed all chemical substances found on the mine property, and recorded information concerning miners' potential exposures to chemical and physical agents and ergonomic hazards which were present at the workplaces. All observations were recorded in a format suitable for computer processing.

The NOHSM data represent all mines within the United States and Puerto Rico. During the survey period, there were approximately 8900 mines in the U.S. and Puerto Rico, employing approximately 290,000 miners and associated with 66 distinct mineral commodities. Those mines were represented in the sample by 542 mines. The NOHSM data may be used to estimate the extent to which various chemical and physical agents are used or found in the U.S. mining industry, as well as the number of miners potentially exposed to those agents. Information regarding the use of various methods of control is also contained within the NOHSM data.

The NOHSM data set was initially developed as a point-in-time estimate to be periodically updated. Once the data has been assimilated into a database, the initial estimates will be updated periodically be means of: (a) new information regarding mining industry employment levels; and (b) limited-scope surveys targeted at specific portions of the mining industry.

Publication FY91: None

HEARING CONSERVATION AND AUDIOMETRIC DATABASE ANALYSIS (HC&ADBA) FOR NOISE EXPOSURE, NOISE-INDUCED HEARING LOSS, AND COMBINED EFFECTS OF NOISE AND OTHER AGENTS ON HEARING

Division of Biomedical and Behavioral Science
Physical Agents Effects Branch
Bioacoustics and Occupational Vibration Section

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HC&ADBA (Hearing Conservation and Audiometric DataBase Analysis) is a system of electronic records management that can accommodate information on occupational and non-occupational noise exposure histories, hearing protector use, medical histories, current noise exposure levels, audiometric records, chemical exposure information, and neurologic screening tests.

The utility of this database in assessing the effectiveness of site-specific hearing conservation programs is currently being investigated through analysis of data on auto workers. Data provided by the U.S. Army and the U.S. Navy will also be analyzed during 1992 and 1993 to determine hearing conservation program effectiveness.

Data from three sites are currently maintained in the database. At present, these data are useful only for providing site-specific information, since neither the sites nor the workforces are representative of any particular industry or population at risk. However, the database as currently structured has potential utility for public health-based surveillance of noise-induced hearing loss.

Publications in FY91: None

QUALITY ASSURANCE OF NEUROBEHAVIORAL TESTING IN NHANES III

Division of Biomedical and Behavioral Science
Applied Psychology and Ergonomics Branch
Neurobehavioral Research Section

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The third National Health and Nutrition Examination Survey (NHANES III) is being conducted by the National Center for Health Statistics (NCHS). The survey includes three computer-administered tests of neurobehavioral function. NIOSH is assisting NCHS by monitoring the quality of the data collected during this testing.

The Neurobehavioral Research Section (NRS) receives raw data directly from the Mobile Examination Centers in the form of computer diskettes. With the assistance of the DBBS Statistics Activity, we review the data to determine if they fall within acceptable limits. A summary report on each diskette is sent to NCHS as quickly as possible (usually within one week of receipt of the data). These summary reports are collected and disseminated, on a monthly basis, to other professionals for additional review.

At least twice a year NRS staff conduct site visits to the Mobile Examination Centers to observe individual test administrators and examine test equipment. These site visits are conducted to insure that the neurobehavioral testing is being done properly.

Efforts are expected to continue through 1994.

Publications in FY91: None

CONTROL TECHNOLOGY FOR NIOSH SURVEILLANCE ACTIVITIES

Division of Physical Sciences and Engineering
Engineering Control Technology Branch
Control Section 2

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In 1987 NIOSH initiated the SENSOR program (Sentinel Event Notification System for Occupational Risks), a cooperative state-federal effort designed to develop local capability for the recognition, reporting, and prevention of selected occupational disorders. Early in 1988, an informal assistance agreement was established between the New Jersey Department of Health and the NIOSH Division of Physical Sciences and Engineering (DPSE) to provide engineering consultation in the control of health hazards in industrial plants. Similar agreements were later established with health departments in Ohio, California, Michigan, and Colorado. Joint follow-back studies were conducted in plants with identified cases of disease in these states. These studies were intended to serve a variety of functions. First, specific control recommendations could be developed to eliminate future cases of disease in the facility of interest. Second, high- hazard industries could be identified for additional study by DPSE. Third, state personnel could accompany NIOSH staff, providing training in survey techniques and in the application of engineering controls. Training courses in the application of control technology and in the use of real-time instrumentation to identify intervention points were also provided, further building the capacity of these state health departments to conduct in-plant follow-back investigations.

Publications in FY91:

O'Brien DM, Froehlich PA, Gressel MG, Hall RM, Clark NF, Bost P, Fischbach TJ [1992]. Silica exposure in hand grinding steel castings. *Am Ind Hyg Assoc J.* 53(1):42-48.

QUALITY ASSURANCE OF SPIROMETRY TESTING IN NHANES III

Division of Respiratory Disease Studies
Clinical Investigations Branch

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In 1988 the National Center for Health Statistics (NCHS) began NHANES III, a cross-sectional survey designed to collect health data from the general population. The survey includes spirometry to be conducted on all subjects over the age of eight. NIOSH, Division of Respiratory Disease Studies (DRDS), supports the spirometry component of NHANES III by providing technical assistance in the form of a comprehensive quality control program and instrumentation.

DRDS has developed a quality control program for NHANES III consisting of the following four functions:

Training: NHANES III technicians attend a minimum of a full week of training at NIOSH, completing the NIOSH approved Spirometry course. Site visits are conducted by DRDS staff to monitor techniques and procedures. Individual quality assurance reports are generated for each technician and reviewed following each stand. Annual refresher sessions are provided to maintain skills.

Data Processing: The NIOSH data coordinator receives and processes data on a daily and weekly basis and at the end of each stand. Spirometric data is assessed for possible technician error and syringe calibration results are reviewed to detect equipment problems or technician procedural errors.

Quality Control: Quality control consists of the selection and adherence to standards with careful checks on both instrumentation and technician performance. This reduces the probability of errors and maintains high quality data. All spirometry equipment and software used by NHANES III is supplied and maintained by NIOSH.

Generation of Individual Participant Summary Report: These reports contain a summary of the participants' spirometry results and an interpretation of the results. They are sent to NCHS project directors who compile each NHANES III participants' complete examination results.

Efforts are expected to continue through 1994.

Publications in FY91:

Hankinson JL, Bang KM [1991]. Acceptability and Reproducibility Criteria of the American Thoracic Society as Observed in a Sample of the General Population. *Am Rev Respir Dis* 143:516-521.

NATIONAL CONFERENCE ON STATE-BASED OCCUPATIONAL HEALTH AND SAFETY ACTIVITIES

CDC, NIOSH
Office of Deputy Director

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A four day conference organized by NIOSH and jointly sponsored by the Centers for Disease Control (NIOSH, National Center for Health Statistics, Public Health Practice Program Office) and the Department of Labor (Occupational Safety and Health Administration, Bureau of Labor Statistics) was held in Cincinnati, Ohio on September 3-6, 1991.

The theme of this first National Conference on State-Based Occupational Health and Safety Activities was "Building State Capacities to Assure Safe and Healthful Working Conditions for All." The conference, which was attended by 400 people from 35 state and federal agencies, served as a forum for presenting the results of state-based efforts in occupational health and safety, including state-based surveillance activities.

Abstracts relating to surveillance activities are reprinted in Part IV of this report and are listed in the Table of Contents.

PART II

NIOSH FY91 Surveillance Activities and National Priorities for Occupational Disease and Injury Prevention

In this section of the NIOSH Surveillance Report for FY91, the surveillance activities described in Part I will be viewed in terms of their ability to address two nationally-promulgated sets of goals for prevention of occupational disease and injury: *Healthy People 2000: National Health Promotion and Disease Prevention Objectives* and the NIOSH List of 10 Leading Work-Related Diseases and Injuries in the United States.

NIOSH FY91 Surveillance Activities and the Healthy People 2000 Occupational Safety and Health Objectives

Healthy People 2000: National Health Promotion and Disease Prevention Objectives[1] was published by the Department of Health and Human Services in 1991. The document was compiled by the Public Health Service and the Institute of Medicine of the National Academy of Sciences, with input from thousands of health professionals, health advocates, and consumers from across the country. It outlines a national strategy for significantly improving the health of the Nation in the 1990's and includes 15 occupational safety and health objectives.

Table I briefly describes each of the *Healthy People 2000 Objectives for Occupational Safety and Health* and lists FY91 NIOSH surveillance activities providing information useful for tracking achievement of each objective.

Table I lists numerous activities useful for tracking Year 2000 Objectives. However, with few exceptions (i.e., Objectives 10.1, 10.8, 10.11), NIOSH surveillance activities fail to provide national surveillance data which systematically track these objectives. For activities utilizing national survey data (e.g., National Occupational Exposure Survey, National Health Interview Survey Occupational Supplement), periodic repetition of these national surveys would provide the longitudinal data needed for surveillance. For activities utilizing data from State-based surveillance programs (e.g., Sentinel Event Notification System for Occupational Risks), the participation of additional States could enable the data to be useful for national surveillance.

NIOSH is not the only Federal agency with occupational health surveillance activities and responsibilities. Other agencies within the U.S. Public Health Service (e.g., Office of Disease Prevention and Health Promotion, other Centers in the Centers for Disease Control) and agencies within the U.S. Department of Labor (e.g., Bureau of Labor Statistics, Occupational Safety and Health Administration, Mine Safety and Health Administration) either conduct such surveillance or gather data that could be used for such surveillance. While the information available within a given agency may not in itself constitute a national surveillance system, putting together fragmentary but complementary data from various sources could provide more comprehensive surveillance for a given objective.

TABLE I

NIOSH Surveillance Activities Providing Information for tracking Year 2000 Objectives

Objective Number	Brief Description	NIOSH Surveillance Activities	Other Federal Agencies with Surveillance Data for Objective
10.1	Reduce deaths from work-related injuries	Fatal Accident Circumstances & Epidemiology National Traumatic Occupational Fatality Database	BLS OSHA MSHA
10.2	Reduce non-fatal work-related injuries	Analysis of National Health Interview Survey Data Construction Trades Surveillance Sentinel Event Notification Systems for Occupational Risk	BLS OSHA MSHA
10.3	Reduce cumulative trauma disorders	Analysis of National Health Interview Survey Data Sentinel Event Notification Systems for Occupational Risks National Occupational Exposure Survey National Occupational Exposure Survey-Mining	BLS MSHA
10.4	Reduce occupational skin disorders	Analysis of National Health Interview Survey Data	BLS MSHA
10.5	Reduce work-related hepatitis B infections	None	CID
10.6	Increase employee seatbelt use	None	ODPHP NHTSA
10.7	Reduce noise exposure	National Occupational Exposure Survey Hearing Conservation & Audiometric Database Analysis	BLS OSHA MSHA
10.8	Reduce blood lead exposure	Blood Lead Surveillance National Occupational Exposure Survey	BLS OSHA MSHA
10.9	Increase hepatitis B immunization among occupationally exposed workers	None	None*

10.10	Implement state-based programs	None	None*
10.11	Prevent exposures causing occupational lung diseases	Analysis Medicare Provider & Review Records Analysis NCHS Multiple Cause of Death Tapes Analysis NCHS National Health Interview Survey Analysis NCHS National Hospital Discharge Survey Analysis of OSHA, MSHA, state exposure data Construction Trades Surveillance National Coal-Workers Autopsy Study National Coal-Workers X-Ray Surveillance Program National Occupational Health Survey of Mining Sentinel Event Notification Systems for Occupational Risks	BLS OSHA MSHA
10.12	Increase number of worksite health & safety programs	National Occupational Exposure Survey	ODPHP
10.13	Increase number of worksites w/back injury prevention and rehabilitation programs	None	ODPHP
10.14	Establish state-based consultation programs for small businesses	None	OSHA
10.15	Increase proportion of primary care providers eliciting occupational histories	None	ODPHP

Abbreviations

BLS: Bureau of Labor Statistics/U.S. Department of Labor
CDC: Centers for Disease Control
CID: Center for Infectious Diseases/Centers for Disease Control
MSHA: Mine Safety & Health Administration/U.S. Department of Labor
NCHS: National Center for Health Statistics/Centers for Disease Control
NHTSA: National Highway Transportation Safety Administration
ODPHP: Office of Disease Prevention and Health Promotion/Public Health Service
OSHA: Occupational Safety & Health Administration/U.S. Department of Labor
*Surveys by Public Health Foundation may contain some relevant data.

NIOSH FY91 Surveillance Activities and the Healthy People 2000 Occupational Safety and Health Objectives

In 1982 NIOSH compiled a list of 10 leading work-related diseases and injuries[2]. Three criteria were used to develop the list: the frequency of occurrence of the disease or injury, its severity in the individual case, and its amenability to prevention.

Table II lists these ten diseases and injuries, along with the FY91 NIOSH surveillance activities which provide data relevant to each condition. These data may fulfill one or more of the following surveillance roles: defining the magnitude of the problem, tracking trends, identifying risk factors or high-risk groups for intervention, evaluating the effectiveness of interventions, and identifying new problems.

Like Table I, Table II reflects considerable NIOSH surveillance activity. Also like Table I, however, Table II contains few activities that in themselves constitute true national surveillance systems for their target conditions. There is currently no NIOSH surveillance activity addressing work-related reproductive disorders.

Surveillance Needs

Tables I and II underscore the following surveillance needs:

1. Further coordination with other agencies, including federal and state Occupational Safety and Health Administrations, the Bureau of Labor Statistics of the U.S. Department of Labor, other centers in the Centers for Disease Control, state departments of health and labor, and workers' compensation bureaus, to systematically ascertain what surveillance data are currently available, how these data may be utilized most productively, and where additional surveillance data are needed to track the Year 2000 Objectives and address the NIOSH List of 10 Leading Work-related Conditions;

2. Intensification of efforts within NIOSH to utilize existing data and, where necessary, collect additional data to address these two sets of national priorities for occupational disease and injury prevention.

It is anticipated that future reports will address more substantively the types, quantity, and quality of surveillance data available from these various sources.

[1]U.S. Department of Health and Human Services, Public Health Service [1991]. *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. U.S. Government Printing Office, DHHS Publication No.(PHS) 91-50212.

[2]Centers for Disease Control [1983]. Leading work-related diseases and injuries–United States. *MMWR* 32:24-26.

Table II

Surveillance Projects Addressing NIOSH List of 10 Leading Work-related Conditions

CONDITION	NIOSH SURVEILLANCE PROJECTS
Occupational Lung Diseases	Analysis of National Health Interview Survey Data Construction Trades Surveillance Development of Respiratory Disease Surveillance Systems Farm Family Health and Hazard Surveillance Mortality Surveillance of Occupation & Industry National Coal Workers Autopsy Study National Coal Workers X-Ray Surveillance Program National Occupational Exposure Survey National Occupational Health Survey of Mining Occupational Respiratory Disease in Agriculture Sentinel Event Notification Systems for Occupational Risks
Musculoskeletal	Analysis of National Health Interview Survey Data Construction Trades Surveillance Farm Family Health and Hazard Surveillance National Occupational Exposure Survey National Occupational Health Survey of Mining Sentinel Event Notification Systems for Occupational Risks
Occupational Cancers	Analysis of National Health Interview Survey data Construction Trades Surveillance Development of Respiratory Disease Surveillance Systems Farm Family Health and Hazard Surveillance Mortality Surveillance of Occupation & Industry National Occupational Exposure Survey National Occupational Health Survey of Mining
Severe Occupational Traumatic Injuries	Construction Trades Surveillance Fatal Accident Circumstances and Epidemiology Farm Family Health and Hazard Surveillance National Occupational Exposure Survey National Occupational Health Survey of Mining National Traumatic Occupational Fatalities Occupational Health Nurses in Agricultural Communities Sentinel Event Notification Systems for Occupational Risks
Cardiovascular Diseases	Analysis of National Health Interview Survey Data Mortality Surveillance of Occupation and Industry National Occupational Exposure Survey National Occupational Health Survey of Mining
Disorders of Reproduction	National Occupational Exposure Survey National Occupational Health Survey of Mining
Neurotoxic Disorders	Analysis of National Health Interview Survey Data Construction Trades Surveillance Farm Family Health and Hazard Surveillance Laboratory-based Surveillance for Elevated Blood Lead Quality Assurance of Neurobehaviroal Testing in NHANES III National Occupational Exposure Survey National Occupational Health Survey of Mining
Noise-induced Hearing Loss	Analysis of National Health Interview Survey Data Farm Family Health and Hazard Surveillance Hearing Conservation & Audiometric Database Analysis National Occupational Exposure Survey National Occupational Health Survey of Mining
Dermatological Conditions	Analysis of National Health Interview Survey Data Farm Family Health and Hazard Surveillance National Occupational Exposure Survey National Occupational Health Survey of Mining
Psychological Disorders	Construction Trades Surveillance Farm Family Health and Hazard Surveillance Occupational Psychological Disorder Surveillance

PART III

Reprints of FY91 Publications Related to NIOSH Surveillance Activities

American Journal of Public Health

Reprint

Female Homicides in United States Workplaces, 1980–1985

Catherine A. Bell

ABSTRACT

Background: Women, while noted for low occupational injury mortality rates, are more likely to die as victims of assault than from any other manner of injury at work.

Methods: From the National Traumatic Occupational Fatality surveillance data, 950 women were identified who were fatally assaulted at work. Homicide rates were calculated for the demographic and employment characteristics of these women. Risk ratios among types of lethal injuries were examined.

Results: During 1980–1985, the crude six-year workplace homicide rate was 4.0 deaths per million working women: one twentieth the homicide rate of the US female population. Decedents ranged from 16 years (the lowest age included in the data base) to 93 years of age. Working women older than 65 years had the highest age-specific homicide rate, 11.3 per million. Women younger than 20 had the lowest, 2.5 per million per year. Homicide rates for women of races other than White were nearly twice as high as those of Whites.

The leading causes of death were gunshot wounds (64 percent), stabbings (19 percent), asphyxiations (7 percent), and blunt force trauma (6 percent). Nearly 43 percent of the deceased women had been employed in retail trade: 8.7 per million employed women annually.

Conclusions: During 1980–1985, only 6 percent of the nation's victims of work-related injury deaths were female: 41 percent of those women were murdered. Homicide is currently the leading manner of traumatic workplace death among women in the United States. (*Am J Public Health.* 1991; 81:729–732)

Introduction

Injury surveillance conducted by the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research, has shown that from 1980 through 1985, homicide was the third leading manner of workplace death in the United States, surpassed only by motor vehicle crashes and machine-related fatal injuries. Nearly 13 percent of all occupational injury deaths were homicides. During 1980–85, 47 percent of the United States work force was female,[1] yet only 6 percent of the nearly 7,000 annual fatal work-related injuries were suffered by women: 41 percent of these women were homicide victims.[2]

Two state-based studies have shown that homicide is a prominent form of lethal occupational injury among women. In a study of fatal work-related injuries in Texas, 1975–80, 53 percent of the 348 women were murdered.[5] Only 13 percent of the fatally injured men were homicide victims.[6] The occupational homicide rate for women was one-third that for men: 7 per million employed women per year compared to 21 per million employed men. In California during 1979–81, the rate of work-related homicide among employed women was 5 per million compared to 22 per million among men.[7] Both studies showed that while a woman was at lower risk of being murdered at work than a man, a greater proportion of female traumatic occupational deaths were due to homicide.

Recently, NIOSH began using demographic and injury event information from state death certificates to examine US fatal occupation injuries, including homicides. This report describes the female victims of work-related homicide during 1980–85, as reported to the National Traumatic Occupational Fatality (NTOF) surveillance system.

Methods

The NTOF data base is composed of death certificates from all state vital statistics reporting units in the US that meet the following criteria: 1) age at death—16 years or older; 2) a positive response to the "Injury at Work" item; and 3) an external cause of death (International Classification of Diseases, Ninth Revision, E800-E999). The methods and limitations that pertain to NTOF injury surveillance are described fully elsewhere.[8]

All NTOF records of female deaths from 1980 through 1985 that reported homicide as the manner of death were selected for this analysis. Homicide, death due to injuries purposely inflicted by another person, was identified using the element in Part II of the death certificate that queries "Accident, Suicide, Homicide, or Pending" because not all NTOF records had coded cause of death information at the beginning of the study. No effort was made to exclude deaths due to legal intervention. Recording practices in Louisiana, Nebraska, New York, and Oklahoma prevented identification of work-related

From the National Institute for Occupational Safety and Health in Morgantown, WV, where the author was with the Division of Safety Research at the time of the study. Address reprint requests to Chief, Injury Surveillance Section, Division of Safety Research, National Institute for Occupational Safety and Health, S-109, 944 Chestnut Ridge Road, Morgantown, WV 26505. This paper, submitted to the Journal February 20, 1990, was revised and accepted for publication February 19, 1991.

TABLE 1—Female Occupational Homicides in the United States[a] by Year, 1980–85: Numbers and Annual Rates[b]

Year	Number	Deaths per 1,000,000
1980	176	4.75
1981	163	4.36
1982	171	4.44
1983	143	3.65
1984	147	3.59
1985	150	3.57
All Years	950	4.04

[a]Excluding deaths from Louisiana, Nebraska, New York, and Oklahoma.
[b]Deaths per 1,000,000 workers.

TABLE 2—Female Occupational Homicides in the United States[a] by Age, 1980–85: Numbers and Six-year Rates[b]

Age (years)	Number	Deaths per 1,000,000
16–19	43	2.50
20–24	155	4.47
25–34	286	4.34
35–44	159	3.17
45–54	138	3.81
55–64	101	4.11
65+	68	11.28

[a]Excluding deaths from Louisiana, Nebraska, New York, and Oklahoma.
[b]Deaths per 1,000,000 workers.

intentional injuries over the study period, so homicide data from these four states were not available.

Employment information was coded from the "usual" industry and occupation entries on the certificates. The Standard Industrial Classification[9] system was used to categorize usual industry of employment. Occupation information was coded into major groups with the 1970 Bureau of Census Classifications for deaths in 1980 through 1982 and the 1980 Bureau of Census Classifications for deaths in 1983 through 1985. The two coding schemes ensured agreement between incidence and underlying employment information because the source of the population data used in the rate calculations changed coding schemes in 1983.[10,11]

To calculate mortality rates, the Annual Summaries of EMPLOYMENT AND EARNINGS[12] provided denominator data for the US. The GEOGRAPHIC PROFILE OF EMPLOYMENT AND UNEMPLOYMENT[13] was used to correct the denominator data used in age-, race-, and employment-specific rates by excluding the estimated work force of the four states which did not provide homicide data to NTOF (nearly 10 percent of the female work force of the US).

Homicide frequencies and annual and six-year mortality rates were calculated for demographic and employment characteristics. Victims whose occupations or industries of employment were unclassifiable were not included in employment-specific rate calculations, although they were included in all other rates. Age- and race-specific rates were estimated. Race-specific rates were calculated for Whites (including Hispanics), Blacks, and Others (Asians and American Indians). Definitive employment data were not available for Hispanics, Asians, or American Indians. Risk ratios (RR) contrasting types of injury (e.g. firearms versus not firearm) within racial subsets were estimated.

Deaths assumed to involve close physical contact, such as stabbing or beating, were compared to those resulting from gunshot wounds that could be inflicted from a distance. Two categories of close physical contact deaths were defined: multiple stabbing and a broader category that included all rape, stabbing, slashing, blunt force, and manual asphyxiation deaths. These were contrasted to the gunshot wounds through risk ratio estimates. Ninety-five percent Taylor Series confidence intervals were constructed around all risk ratio estimates.[14]

Results

NTOF data described 950 women who were murdered at work during 1980–85 (Table 1). The women's ages ranged from 16, the youngest documented in NTOF data, to 93 years. The six-year age-adjusted homicide rate was 4.5 deaths per million working women. The highest homicide rate, 11.3 per million, was among working women 65 years of age and older (Table 2).

Black women were 1.8 times more likely to be killed than Whites. The RR for homicide among Blacks contrasted to all other women was 1.7 (95% CI: 1.4, 2.0) and for the Other racial category was 1.9 (95 % CI: 1.4, 2.5). Hour of injury was reported for 680 cases: homicides were most frequent between 4:00 and 5:00 pm. However, 30 percent of the women were murdered between 6:00 pm and midnight and 69 percent died between 3:00 pm and 7:00 am.

Industry of Employment

Nearly 43 percent of the homicide victims were employed in the Retail Trade Industry which also had the highest six-year homicide rate, 8.7 per million retail employees. Forty-one percent of these women worked in food stores, and 34 percent in eating and drinking establishments.

The Transportation, Communication, and Public Utilities Industry had the second highest rate, 4.0 per million: 34 percent were employed in motor freight transportation and warehousing and 18 percent in local passenger transportation with buses and taxis. While 23 percent of the women worked in the Service Industry, their homicide rate was quite low, 2.22 per million: 22 percent of these women worked in education, 16 percent in health services, and 13 percent in hotels, motels, and other lodging.

In Public Administration, 33 percent of the women were employed in justice, public order, and safety, 28 percent in general government, and 23 percent in the military. Industry of employment was not coded for 14 percent of the decedents, due to lack of specific employment information on the death certificates (Table 3).

Occupation

Despite the changes in the occupation classification schemes in 1983, 71 percent of the murdered women were employed in only four occupational groups: sales personnel (n = 184), clericals (n = 169), service employees (n = 182), and supervisors (executives, managers, and administrators) (n = 151). During 1980-82, retail store clerks and cashiers, classified as clericals, accounted for 26 percent of the decedents' occupations: their homicide rate was only 3.4 per million. Sales workers, such as sales clerks and owners of retail establishments, died at a rate of 8.3 per million. During the next three years, retail clerks and cashiers were classified as sales occupations. These accounted for 27 percent of the 1983–85 deaths with a three-year rate of 7.6 per million.

For the six-year period, 105 of the 175 women in service occupations were employed in eating and drinking establishments. At least 52 of these worked in bars, taverns, or lounges. Nineteen women were employed as law enforcement officers or security guards. Lack of national

TABLE 3—Female Occupational Homicides in the United States[a] by Industry, 1980–85: Numbers and Six-year Rates[b]

Industry	Number	Deaths per 1,000,000
Agriculture/Forestry/Fishing	4	1.11
Construction	6	2.15
Manufacturing	44	1.23
Transportation/Communication/Public Utilities	38	3.97
Wholesale Trade	9	1.52
Retail Trade	405	8.66
Finance/Insurance/Real Estate	55	2.78
Services	219	2.20
Public Administration	40	3.92
Not Classified	130	—

[a]Excluding deaths from Louisiana, Nebraska, New York, and Oklahoma.
[b]Deaths per 1,000,000 workers.

estimates for employment in these specific occupations made rate calculations impossible.

Employment as a supervisor increased a woman's risk of homicide. Decedents most commonly managed restaurants, apartment complexes, or retail establishments. Ten percent of the women owned their own businesses.

Region

Only 24 (3 percent) of the women were murdered outside the states where they resided. Despite the lack of reporting from Louisiana and Oklahoma, over half (52 percent) of the murders took place in the South at a rate of 5.7 per million women working in the reporting states. The Western states had the second highest rate, 4.1 per million, and 23 percent of the homicides. The North Central states, where Nebraska deaths were not reported, had a homicide rate of 2.5 per million and 18 percent of the deaths. Only 7 percent of the fatalities were reported from the Northeast at a rate of 1.2 per million. This region's figures are seriously compromised by the omission of New York deaths from the data. Of the 46 states reporting, rates indicated that women were at highest risk of being murdered at work in Nevada, Mississippi, the District of Columbia, Florida, and Texas.

Method of Homicide

Firearm injuries caused 609 deaths (64 percent): 148 (16 percent) noted multiple gunshot wounds. Stabbing and slashing caused 181 deaths (19 percent). Multiple stabbing was mentioned in 103 cases (11 percent). Decedents were asphyxiated in 69 (7 percent) or died from blunt force injuries in 57 (6 percent) of the cases. Together, fires, explosions, motor vehicle impacts, poisoning, and sexual assault were reported in fewer than 4 percent of all cases.

Lethal gunshot wounds were most frequent in the 25–54 year age range. The firearm homicide rate among Black females averaged 4.4 per million compared to 2.2 per million among Whites. Black women were slightly more likely to die from gunshot than other wounds (RR, 1.1, 95% CI: 1.0, 1.2). The risk of Hispanic women dying from firearm relative to other injuries (RR) was 1.4 (95% CI: 1.2, 1.6).

Multiple stabbings were prominent, but not significantly elevated, among the oldest women. However, the risk of an elderly woman dying from any form of physical contact relative to gunshot wounds (RR) was 3.6 (95% CI: 2.6, 4.9). Asian and American Indian women were slightly more likely to be killed in trauma involving physical contact than from gunshot wounds (RR of 1.4, 95% CI: 1.0, 2.0), while Black women were more likely to die from gunshot wounds (RR = 0.7, 95% CI: 0.5, 0.9).

Discussion

While the limitations of death certificate information in general[15–18] and NTOF in particular[8] have been well defined, a few merit discussion in terms of occupational homicide surveillance. Surveillance based on death certificates alone underreports cases of fatal occupational injuries. State studies have shown between 67 percent and 88 percent of all traumatic workplace deaths can be identified using death certificates alone.[19] Legal sources such as police files and medical examiner records are more detailed; however, they do not regularly identify work-related cases and are not readily accessible in most US jurisdictions. Death certificates provide systematic accounts of each traumatic death in the US, and not those reported to have occurred at work. Death certificates record "usual" occupation and industry of employment, not necessarily employment at the time of injury. Studies show that between 64 percent and 74 percent of reported usual occupations correspond with decedents' most recent occupations, and between 60 percent and 76 percent of the usual industry entries correspond with most recent industries of employment.[16-18]

Both formal state policies and individual practices affect case ascertainment and data accuracy. The most notable weakness is lack of standard criteria for completing the injury at work item; it is not rigorously defined and is subject to interpretation. For example, in Louisiana a state policy existed where "injury" was interpreted as "accidental injury." Until 1985, the injury at work item was not completed for intentional injuries. Even when injuries that take place at work are correctly recorded, some states automate that information only for unintentional injuries. In these states all homicides and suicides must be screened to find each noted as having occurred at work. This screening is tedious and through human error intentional injury cases may be missed.

A certifier may also impose an idiosyncratic definition of work that excludes or obscures employment. No prostitutes or illicit drug dealers are identifiable in the NTOF data. Juveniles are rarely considered "at work." Deaths perpetrated by acquaintances or family members may be screened by a certifier who considers "at work" to mean solely work-related. Homicides are also misclassified as accidents, suicides, or deaths of undetermined cause. For such reasons, the cases here underreport victimization among working women in the US.

While such factors can hinder hazard identification and ultimately injury control, NTOF surveillance rapidly identified homicide as the major occupational hazard for the nation's women. Homicide risk may be associated with exposure to the public, the exchange of money, and evening employment.[5–7,20] Women employed in the retail industry, particularly in food stores, were at greatest risk. Many owned or managed groceries, taverns, and restaurants. Elevated homicide rates in

motor freight and warehousing, local passenger transportation, government, and law enforcement call for heightened safety for workers in these jobs. Detailed studies of homicide risk in education, health services, hotels, motels, and other lodging places are also warranted.

The role of victim age in these deaths is still not clear. Older women may be attractive targets and/or less likely to survive traumatic assault. This analysis also showed that older women were often self-employed or small-business owners. While Davis, *et al*, argued that high workplace homicide rates in Texas women age 65 years or older did not result from underenumerated employment,[5] the person-year denominators used in the NTOF age rates may distort the risk estimates. For example, low rates among young women may reflect part-time work. Age-specific homicide rates should be examined using hour-based employment information when available.

Most of the women died from gunshot wounds. Close physical contact deaths were significantly elevated among older White women and among Asians, a group generally noted for low risk of violent death.[21] Because control strategies may depend on discrimination between robbery assault and personal or sexual violence, more detailed studies are needed on the circumstances of workplace homicides.

At least one major convenience store chain has implemented robbery deterrence programs which couple behavioral and environmental components.[22] In evaluated programs, employees have been trained in techniques of conflict resolution and nonviolent response.[21–24] Locked drop-safes, well-lit parking lots, and a work area openly visible to the public are environmental components that appear to reduce robbery and associated mortality.[22]

Convenience stores are essentially small businesses with control strategies that might prove useful in small, owner-operated businesses. Before recommending use of their control strategies developed in other environments, performance in the new environment should be rigorously evaluated.

Hazardous industries may also benefit from regulation, particularly where employers have not reduced homicide risk. The Occupational Safety and Health Administration (OSHA) standards do not yet explicitly address safety from workplace violence, but an increasing number of local ordinances mandate hours for store operation or the presence of multiple employees. The next step in reducing the risk of workplace homicide is to evaluate the effectiveness in various work settings of existing as well as new control strategies. □

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Preventable Mortality in the Restaurant Industry. C. Burnett,* J. Gittleman, and N. Lalich (NIOSH, Cincinnati, OH 45226).

The US restaurant industry employed about 6 million workers in 1985. The availability of alcohol and high fat foods and the probable exposure to tobacco smoke in the workplace may put these workers at high risk for a number of diseases that cause premature death. Proportionate mortality ratios (PMRs) were used to analyze coded data from over 1,000,000 death certificates from 23 states for 1979–1987 for decedents aged 15–64 years. Included were over 20,000 decedents whose usual job was reported to be in the restaurant industry. Strong effects of life-style are seen in this industry. Many PMRs for alcohol-related deaths were elevated. Alcoholism or chronic liver disease and cirrhosis PMRs were elevated more than 50% for white men who were bartenders, waiters, or cooks, white women who were bartenders or waitresses, and black waiters and waitresses. In addition, white male bartenders and white waitresses had elevated PMRs for cancers of the upper alimentary tract and the larynx, i.e., cancers associated with alcohol and smoking. The PMRs for drug-related deaths were elevated for black and white waiters and waitresses and white male bartenders both for the 15–64 years age group and also in the subgroup 15–24 years old. White waitresses had elevated PMRs for many smoking-related conditions. Of interest are the elevated PMRs for diabetes mellitus in all four race-sex groups. Health promotion and wellness programs are greatly needed in the restaurant industry.

Ergonomics in the Workplace:

A Survey of a Santa Clara County-Based Business Association

Report No. SR90-004

California Occupational Health Program
California Department of Health Services
2151 Berkeley Way, Annex 11
Berkeley, CA 94704

February 27, 1991

Acknowledgements

This report was prepared by staff of the California Occupational Health Program (COHP) in close cooperation with committee chairpersons from a large, diverse, business association based in Santa-Clara County. Without the cooperation of the member companies, this report would not have been possible, and their participation is gratefully acknowledged.

This report was done under the auspices of COHP's Sentinel Event Notification System for Occupational Risks (SENSOR) Project, Neil Maizlish, Ph.D., Coordinator, Linda Rudolph, M.D., Principal Investigator. The SENSOR Project is supported by a grant from the National Institute for Occupational Safety and Health, Centers for Disease Control, and done in cooperation with the California Public Health Foundation, Berkeley, CA.

Ergonomics in the Workplace:
A Survey of a Santa Clara County-Based Business Association

Summary

In September 1990, the California Occupational Health Program (COHP) of the California Department of Health Services and a business and industrial association, based in Santa Clara County, jointly conducted a survey of its nearly 300 members about workplace ergonomics. The purpose of this survey was to gather information to gauge how occupational ergonomics and work-related cumulative trauma disorders might be affecting members of this business association, and to help formulate educational activities in response. The survey was conducted in the context of COHP's federally funded SENSOR Project, which is establishing a model program in Santa Clara County for the prevention work-related cumulative trauma disorders (CTDs) such as carpal tunnel syndrome (CTS).

The survey instrument was a two-page questionnaire which was mailed with a business reply envelop to one contact person in each of 294 companies in Northern California. A week before the survey, a news item appeared in the associations monthly newsletter to solicit participation. The questionnaire covered respondent demographics (workforce size, product line), prevalence of cases of cumulative trauma disorders in 1989, health care for industrial injuries and illness, resources to evaluate and respond to ergonomic hazards, success stories in the implementation of ergonomics programs, perceived barriers to the implementation of ergonomics programs, organizational needs for ergonomics, and educational and informational needs on CTDs and ergonomics.

Of 294 companies contacted, 53 (18 per cent) returned completed questionnaires. Nearly half the respondents were representatives of their companies health and safety department (12) or the environmental health and safety department (12). Eight respondents were high ranking company officials (president, vice-president, owner). Engineers (3), operations personnel (3), and human resources (3) representatives were also respondents. The respondents were employed at companies with an estimated California workforce of over 224,000, of which nearly 57,710 were employed at the facilities of the respondents. Almost one-third (17 respondents) were in manufacturing companies: aerospace, heavy equipment, electronics, and scientific instruments; 16 respondents were engineering or environmental consultants; the remaining respondents were from companies engaged in chemical and pharmaceutical research (4), waste disposal (3), construction (2), and public utilities, rehabilitation and career counselling, property and facilities management, and speciality industrial and consumer products.

Nearly 90 per cent believed that repetitive motion can cause occupational injuries or illnesses. Nearly two-thirds of respondents reported cases of cumulative trauma disorders at their companies in recent years (See attached tables).

Based on their previous year's experience, in 1989, pooled together, the 53 respondents were aware of 699 cases of CTDs of the upper extremity (eg. carpal tunnel syndrome, tenosynovitis, etc.), or, on average, 1 per cent of their facilities' workforce (699 cases per 57,710 employees). Fifteen percent indicated that there were no cases at their company in 1989, and about 25 per cent reported 1-4 cases. A small percentage (7 per cent) reported 25 or more cases of CTDs of the upper extremities.

In 1989, pooled together, the 53 respondents were aware of 572 cases of CTDs of the *lower* extremity (eg. low back pain/sprain), or, on average, 1 per cent of their facilities' workforce (572 cases per 57,710 employees). Nearly one quarter of the respondents indicated that there were no cases of lower extremity CTDs at their company in 1989, about 25 per cent quarter indicated that there 1-4 cases. A small percentage (7 per cent) reported 25 or more cases of CTDs of the lower

extremity in 1989. Over 800 workers' compensation claims had been made for CTDs (upper and lower extremities) among the respondents.

Roughly 40 per cent of the respondents did not contract with a particular medical group for treatment of industrial injuries. Respondents for companies that did contract for occupational medical services believed that their provider seemed knowledgeable about workplace ergonomic hazards.

A quarter of the respondents reported that their company had no resources to evaluate or respond to ergonomics hazards, and 30 (57 per cent) reported that their company had no ergonomics program. Many companies included training, industrial hygienists, a health and safety committee, or medical services as resources. Twenty percent reportedly had an ergonomist or ergonomics consultant.

Of the 19 respondents who had implemented an ergonomics program at their facility, nearly all reported benefits. Fifteen companies reported decreases in injury/illness rates and decreases in workers' compensation costs. Additionally, improved productivity, decreased absenteeism, and improved quality were reported by at least half of those who had implemented ergonomics programs.

Barriers to implementing ergonomics programs were experienced by many respondents. Nearly one-half experienced some budget limitation. One-third reported inexperience in dealing with ergonomics and one-third reported lack of management approval or support as barriers. Legal concerns were not reported as a barrier by any respondent.

Twenty-seven respondents (50 per cent) identified specific organizational needs for control and/or prevention of CTDs. Training (15), knowledge (13), expertise or experts (8), resources, including monetary resources (6), and management support (2) were mentioned as organizational needs.

Eighty percent were interested in obtaining more information about CTDs and ergonomics. The majority of respondents (59 per cent) preferred written materials. Respondents were favorably inclined to videos or a half-day training sessions.

Discussion

It is not possible to determine whether the survey respondents are a representative or biased sample of the business association, or whether nonparticipants would be more likely to have high rates of CTDs than participants. The low response rate is not untypical of surveys that rely exclusively on mailed questionnaires.

Nonetheless, results of this survey indicate that cumulative trauma disorders are an important source of industrial injury and illness, accounting for hundreds of cases per year, and many workers' compensation claims. While many respondents have some occupational health and safety resources, few had a specific ergonomics program. In the few cases where ergonomics programs were implemented, a high percentage of the respondents reported decrease in CTD morbidity and cost savings. The overwhelming majority of respondents want more information about CTDs and ergonomics, preferably in a written, video, or short workshop format.

This small sample suggests there are tangible benefits of implementing ergonomics programs, and that widespread adoption of successful ergonomics programs could have a significant impact on preventing morbidity from CTDs.

Ergonomics at the Workplace:
A Survey of a Santa Clara County-Based Business Association

Survey Questions and Results

1. Do you believe that repetitive motion can cause occupational injuries/illnesses?

Yes	47	89%
No	2	4%
Don't Know	4	7%
Total	53	100%

2. Has your company had any reported cases of cumulative trauma disorders in the last several years (eg. carpal tunnel syndrome, tendinitis, low back pain/strain)?

Yes	34	64%
No Cases	14	26%
Don't Know	3	6%
Other	2	4%
Total	53	100%

3. How many cases of CTD's in the hands, arms, neck, and shoulders--upper extremities--(carpal tunnel syndrome, tenosynovitis) were reported in 1989?

None	8	15%
1-4	15	28%
5-9	6	11%
10-24	3	6%
25+	4	7%
Blank*	17	32%
Total	53	99%

4. How many worker compensation claims for upper extremity disorders did you have in 1989?

None	8	15%
1-4	16	30%
5-9	3	6%
10-24	4	7%
25+	4	7%
Blank	18	34%
Total	53	99%

5. How many cases of lower extremity disorders (low back pain/strain) were reported in 1989?

None	13	24%
1-4	9	17%
5-9	5	9%
10-24	5	9%
25+	3	6%
Blank	18	34%
Total	53	99%

6. How many worker compensation claims for lower extremity disorders did you have in 1989?

None	13	24%
1-4	10	19%
5-9	5	9%
10-24	3	6%
25+	4	7%
Blank	18	34%
Total	53	99%

* Blank = nonresponse to survey question

7. Does your company contract with a particular medical group to provide industrial injury treatment?

Yes	28	53%
No	23	43%
Don't Know	1	2%
Blank	1	2%
Total	53	100%

8. Does this health care provider seem knowledgeable about workplace risk factors?

Yes	28	53%
No	3	6%
Don't Know	4	7%
Blank	18	34%
Total	53	100%

9. What resources does your company currently have to evaluate and respond to cumulative trauma disorders and ergonomic hazards? Ergonomic hazards are those work conditions or practices that place excessive biomechanical stress on the worker.

Resource	Yes	%
Ergonomist/Ergonomic Consultant	10	19%
Training Program	22	42%
Industrial Hygienist	18	34%
None	13	25%
Health & Safety Committee	17	32%
Industrial Medicine Consultation	10	19%
Industrial Engineer	6	11%
Other	9	17%

10. Do you have an ergonomics program?

Yes	19	36%
No	30	57%
Blank	4	7%
Total	53	100%

11-12. What successes have you experienced in implementing an ergonomics program in your facility?

Success	Yes	%
Decreased injury/illness rates	15	28%
Improved quality	8	15%
Decreased absenteeism	7	13%
Improved productivity	9	17%
Decreased workers' comp. costs	10	19%
Other	15	28%

* Blank = nonresponse to survey question

13. What barriers have you experienced in implementing an ergonomics program in your facility?

Barrier	Yes	%
Budget Limitations	24	45%
Experience in dealing w/ergonomics	18	34%
Legal concerns	0	0%
Management approval/support	18	34%
Understanding of control strategies	10	19%
Other	6	11%

14. What do you think your organization needs to adequately control or prevent cumulative trauma disorders?

Item	Yes	%
Training	15	28%
Knowledge	13	24%
Expertise/Experts	8	15%
Resources	6	11%
Management Support	2	4%
Better proof of relation between work and CTDs	1	2%

15. Would you be interested in obtaining more information on cumulative trauma disorders and ergonomics?

Yes	43	81%
No	8	15%
Blank	2	4%
Total	53	100%

16. How would you prefer information be presented to your company?

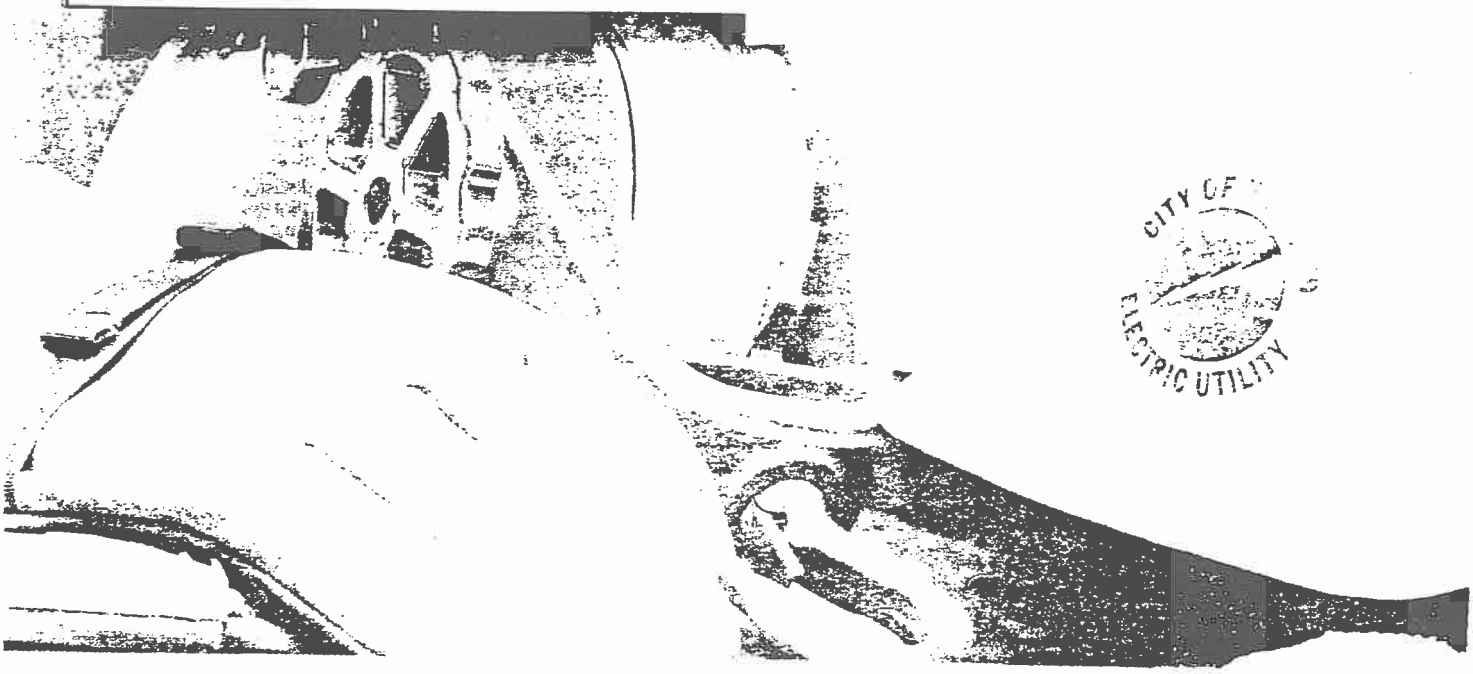
Type of information	Yes	%
Written materials	31	59%
Half day work shop	13	25%
Committee session	5	9%
Full day seminar	9	17%
Video	18	34%
Other	2	4%

* Blank = nonresponse to survey question

Preventing Lineworker Fatalities

by Virgil J. Casini, James W. Collins and John R. Myers

Photos by Bob Cervini



CITY OF
ELECTRIC UTILITY

The National Institute for Occupational Safety and Health is the federal agency responsible for conducting research to identify hazards and developing effective intervention methods to prevent work-related injuries, illnesses, and fatalities. The NIOSH Division of Safety Research is the institute's focal point for fatal and nonfatal traumatic injury research programs. Its mission is to reduce the number and severity of occupational injuries by developing and conducting research projects that yield results with real-world impact.

The Division of Safety Research analyzes occupational mortality and morbidity data to target high-risk industries and occupations for further study. Line mechanics have been identified by NIOSH's National Traumatic Occupational Fatality (NTOF) database as a high-risk occupational group for work-related deaths. The job classification *line mechanic* or *lineman* refers to workers who construct, maintain, or repair transmission and distribution power lines. The NTOF database consists of information from death certificates of workers who died as a result of traumatic occupational injuries that meet the following criteria:

- age at death—16 years or older;
- an external cause of death from the International Classification of Diseases 9th Edition (ICD-9), reported as immediate, underlying or contributory;
- a positive response to the "injury at work" item on the certificate.

From 1980 to 1985, 374 line mechanic deaths were identified by the NTOF database; of these, 59 percent were due to electrocution, 14 percent were due to falls from elevations, and 27 percent were due to other causes such as heavy objects falling on the worker, motor vehicle incidents, burns and explosions. Over that same time period, the average yearly employment of line mechanics was 110,800, according to the Bureau of Labor Statistics. The average annual number of fatalities (62.3 line mechanic deaths per year), divided by the average yearly employment of line mechanics (110,800), indicates an annual fatality rate of 56.3 deaths per 100,000 line mechanics. This rate was significantly higher than the general industry fatality rate of 7.9 deaths per 100,000 workers over the same time period.

Another source of data on lineworker fatalities is the NIOSH Fatal Accident Circumstances and Epidemiology (FACE) project. The objective of the FACE project is to identify factors that contribute to occupational deaths by conducting epidemiologic field evaluations of selected fatalities. As part of the FACE project, Division of Safety Research personnel did 203 evaluations involving 219 electrical-related fatalities during the period November 1982 to December 1990. Of these investigations, 41 involved line mechanics, resulting in 43 fatalities. For fatalities investigated as part of the FACE program, line mechanics were the second most frequently involved job classification; laborers were first. The average age of the line mechanic victims at the time of death was 36 years. Assuming a life expectancy of 65 years for each victim, the years of total potential life lost for the 43 fatally injured line mechanics added up to 1,175 years of life (an average of 27 years per victim). The FACE project personnel investigate fatalities at investor-owned utilities, municipalities, electric cooperatives and electrical contractors. Voltage levels contacted in these incidents ranged from 110 to 230,000 volts.

The U.S. Bureau of Labor Statistics Supplementary Data System also has identified line mechanics as a high-risk group for occupational injuries. The SDS is a composite of workers' compensation claims from approximately 27 participating states. Since only 27 states provided information to the SDS system during the six-year period (1980 through 1985), and not all states participated in all years, the compensation counts provided are not national values. For this six-year period, the SDS system reported a yearly average of 2,024 injuries to line mechanics in the Electric Services Industry (Standard Industrial Classification Code 4911). This information, while not providing a national quantification of line mechanic injuries, does allow for a good classification of line mechanic injuries. Analysis of this data in combination with information from the Bureau of Labor Statistics annual survey, (a national estimate of occupational injuries and illnesses based on a random sample of industries nationwide), indicated that line mechanics have an estimated annual rate of 6.3 lost-workday injuries per 100 workers, nearly twice as high as the annual rate of 3.6 lost workday injuries per 100 workers for all private sector employees.

Using the workers' compensation information from SDS, overexertion and struck-by injuries each accounted for 20 percent of the injuries involving line mechanics. Falls accounted for 18 percent, while contact with electricity was noted as the cause for less than 5 percent. The leading sources of injuries, based on the SDS data, were working surfaces, metal items, electrical apparatus, bodily motion, hand tools and vehicles.

The three leading causes of fatal injury are contact with electrical injury, falls from elevations, and objects falling on line mechanics, while the three major causes of nonfatal, reportable injuries to line mechanics are over-exertion, being struck by falling objects and falls.

Due to inherent hazards involved in the construction, repair and maintenance of electrical transmission and distribution systems, employers typically provide extensive training for line mechanics and require them to adhere to stringent injury prevention and line clearance procedures.

However, the invisibility of electricity makes it difficult for a line mechanic to be constantly aware of the life-threatening hazards presented by working close to power lines. Efforts to maintain continuous electric service to customers frequently dictate that line mechanics repair and maintain transmission and distribution systems while power lines remain energized. Additionally, line mechanics must deal with a constantly changing work environment, inclement weather, working from heights, overtime, and cumbersome personal

and electrical protective equipment.

Four of the FACE field evaluations involving line mechanic fatalities are described below to present typical causative factors that recur in the FACE line mechanic fatality data.

Case No. 1 (NIOSH 1985) A 38-year-old lineworker with 20 years experience was electrocuted while repairing a 13.2-kV line that he thought was de-energized. The lineworker was working from an aerial bucket truck to repair a power line damaged during an electrical storm. The damaged line was one of two power line phases serving a residential area. The third phase of the circuit supplied a three-phase transformer that provided power to a store. To repair the damaged line, both of the residential power lines were presumed de-energized by opening their respective disconnects. However, the third line remained energized to provide power to the store. Because of this, voltage fed back through the three-phase transformer, inadvertently energizing the line on which a splice was to be made. Though the lineworker presumed that the line to be spliced had been de-energized, he tested it for voltage by touching it with insulated pliers held in his gloved hand. When the lineworker did not see an arc or hear a buzzing sound, he concluded it was de-energized, removed his glove, and began to splice the line. Because fuzzing does not adequately detect lower voltages, the worker did not detect the voltage created by the back-feed circuit. [Power company engineers later estimated that the line carried 4,000 to 7,000 volts.] The lineworker inserted the supply side of the line into a splice tube and crimped it. When he grasped the load side of the line, he completed an electrical circuit between the supply and load sides of the line, causing current to pass through his arms and chest, resulting in his electrocution. Grounds had not been placed on the line, and electrically insulated lineworker gloves were not used when the incident occurred.

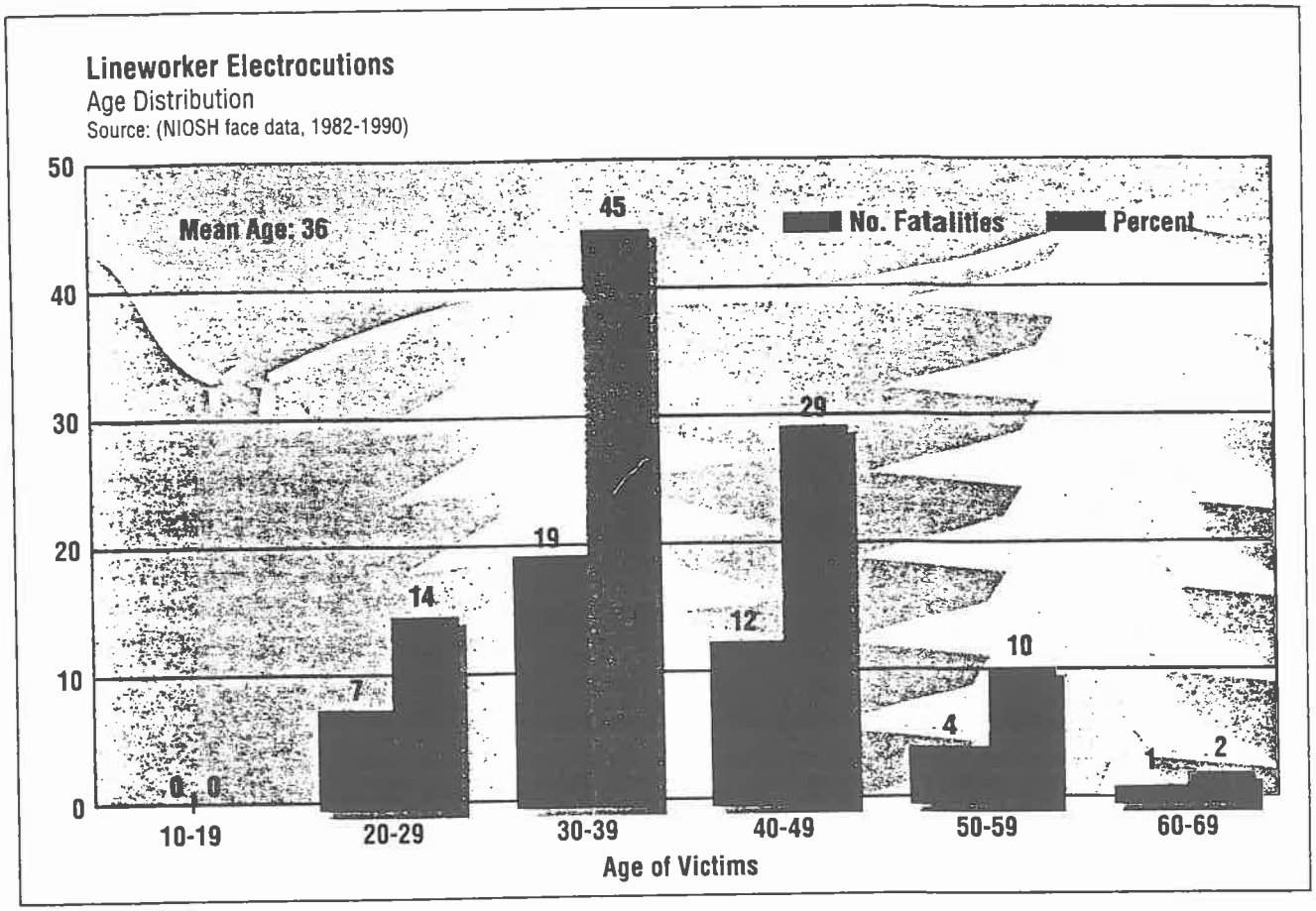
In a multiphase distribution system, the possibility that any one phase can serve as the supply for the transformer should always be considered. Lineworkers should treat all power lines as energized unless they have personally de-energized the power lines, have applied proper grounding to their work area and have tested the line to verify de-energization.

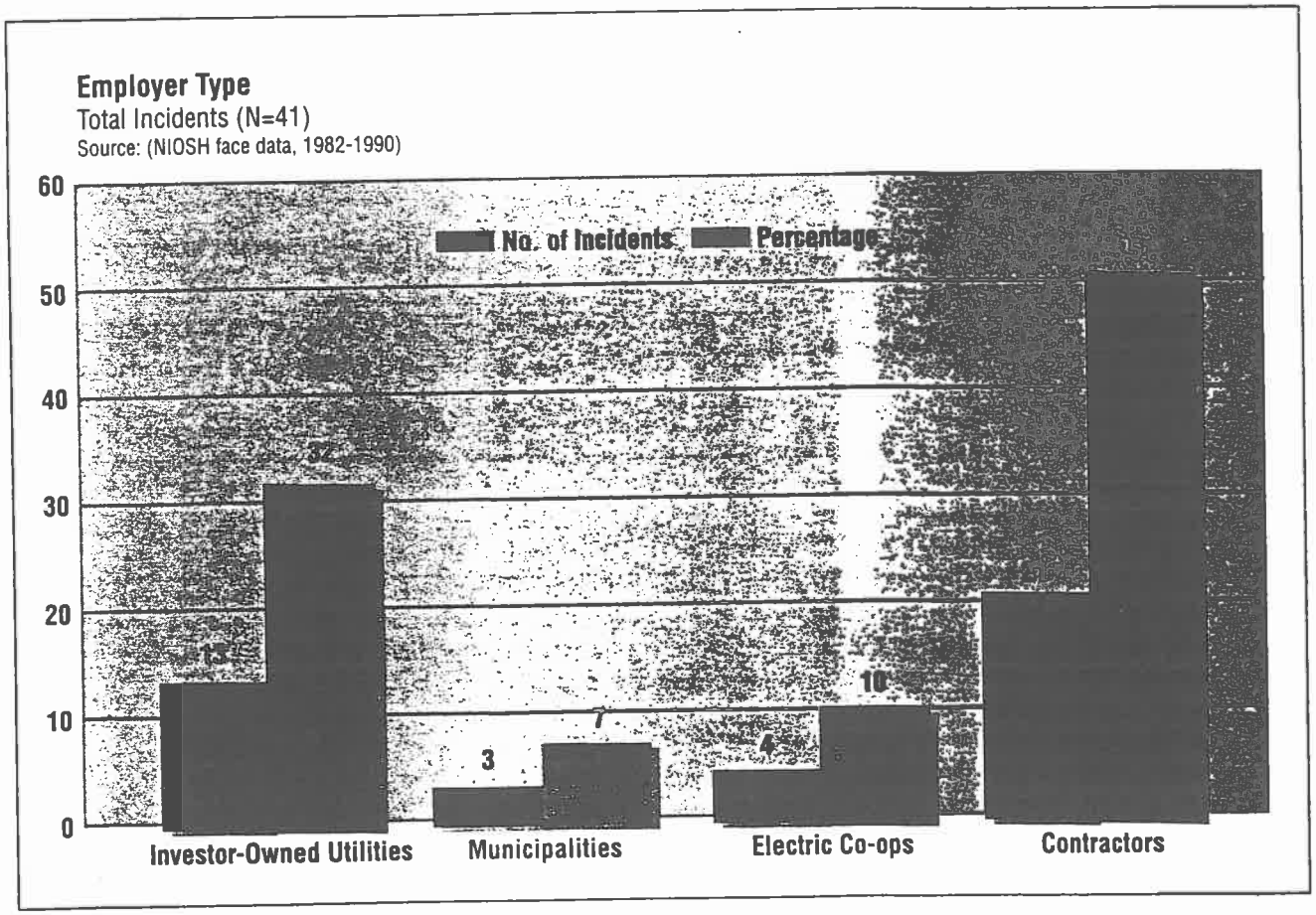
Case No. 2 (NIOSH 1986) A 40-year-old meter technician, who was working overtime as a lineworker technician, was electrocuted while repairing a downed line. The victim had worked as a meter technician constructing, maintaining, and repairing electric meters for the full 20 years of his work life. However, several years earlier, he had attended a seven-week basic lineworker training course which qualified him as a lineworker technician, permitting him to climb poles and work with electrical conductors. During his regular shift, he worked as a meter technician; however, during unplanned power outages, he worked as a lineworker technician restoring electrical service. On the day before the incident, the victim worked more than 14 hours, finishing work at 11:45 p.m. He reported to work at 8 a.m. on the day of the incident and worked his regular shift. Upon completion of his regular shift, he was asked to work overtime to restore electrical service to a residential customer.

At 5:00 p.m., the victim arrived at the site and discovered a tree limb had fallen across a power line. The line had detached two 120-volt conductors and the neutral wire from the utility pole. After removing the tree limb from the conductors, the technician cut the electrical conductors on either side of previous splices, attached a rope to the three conductors, fished the rope through a block and tackle, and attached the rope to the bumper of his utility truck. He then moved the utility truck until all the slack in the conductors was removed between the two utility poles (a span of approximately 130 feet). He then reclimbed the utility pole wearing his insulated gloves, hard hat and safety glasses. The technician was pulling an energized cable when a splice in the cable caught the left cuff of his glove. The cuff of the glove was pulled down, allowing the energized conductor to contact the victim's forearm near the wrist, resulting in his electrocution. The meter technician did not use his lineworker technician training on a regular basis and had been assigned a task that was very difficult to be performed safely by one person.

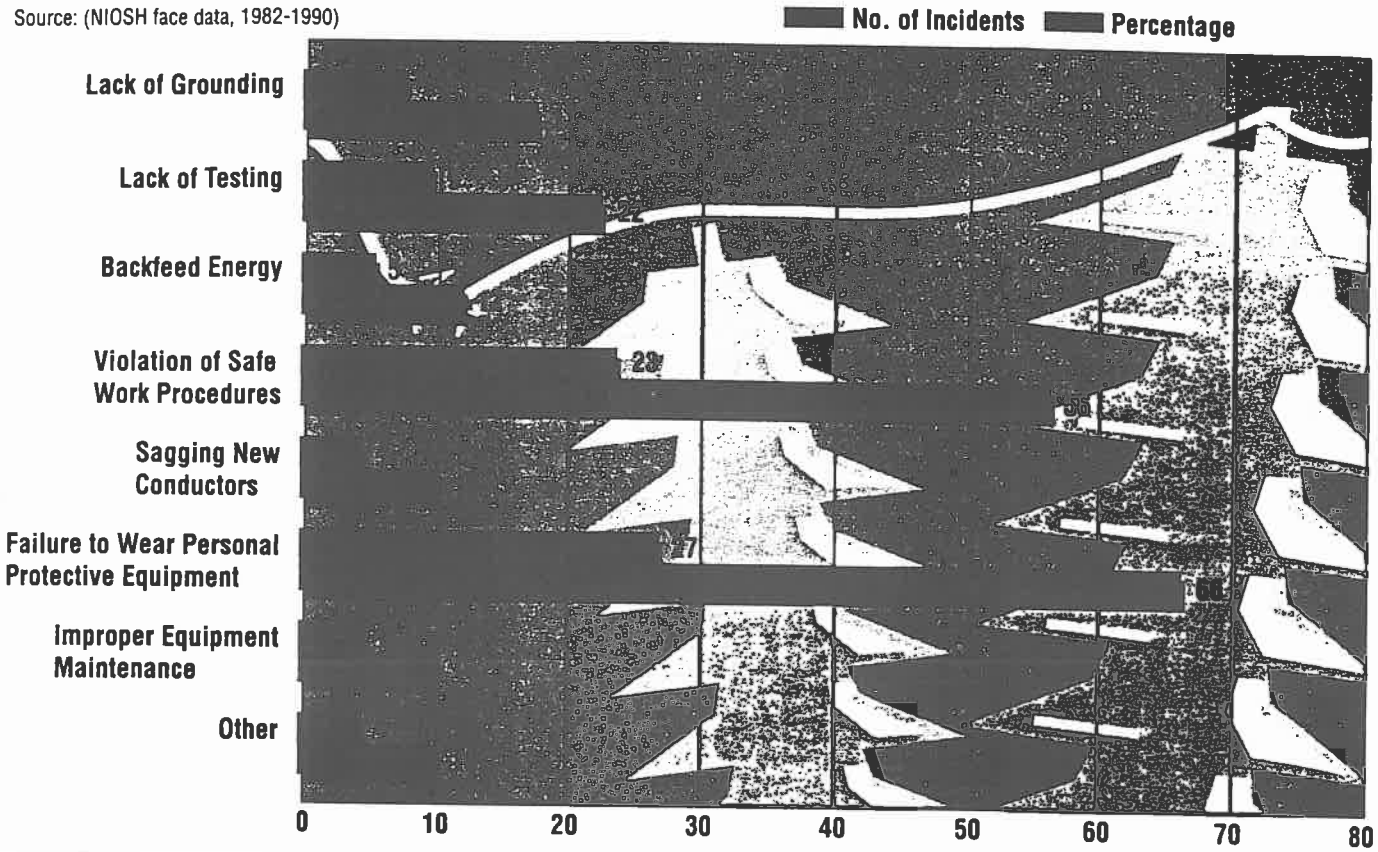
Case No. 3 (NIOSH 1987) A 37-year-old lineworker, who was working for an electrical contractor that specializes in power line construction and maintenance, was electrocuted when the boom of a digger derrick truck contacted a 7,200-volt power line while he was leaning against the truck. The crew consisted of two lineworkers and an apprentice lineworker. One of the lineworkers, who was serving as a working foreman, told the apprentice lineworker where to position the truck and then went over the job procedures with the crew. After the pre-job briefing, the victim began to install the truck's ground rod, which was attached to a 30-foot ground cable. The apprentice lineworker climbed onto the truck's platform and raised the boom. This action was in violation of the contractor's policy that the truck's boom not leave the truck's cradle until the ground has been installed. While it is unknown why the apprentice lineworker raised the boom, it is suspected that he either thought the ground had been installed or he may not have been able to see the victim clearly. The boom contacted the overhead power line, electrocuting the victim.

Case No. 4 (NIOSH 1990) A 46-year-old male distribution line technician working from a tree to clear limbs off a 7,200-volt power line, was electrocuted then fell 20 feet to the ground. The victim and a coworker had been dispatched to an area to clear tree limbs off a 7,200-volt primary power line. The limb damage occurred when a tropical storm passed through the area. An aerial bucket truck could not be used because the dirt access road had been rendered impassable by heavy rains. The victim got a telescopic fiberglass hot stick from the back of his truck and walked the access road with his coworker until he saw a white pine limb lying across the power line. Following standard operating procedure, the victim extended the hot stick and knocked the limb off the power line. The victim retracted the hot stick and was walking toward the truck when he heard a popping sound above him. The victim told the coworker that he thought he saw a second limb contacting the power line at a point where the line passed through the pine tree. Because of the dense


Lineworker Electrocutions
Age Distribution
Source: (NIOSH face data, 1982-1990)
Mean Age: 36
No. Fatalities
Percent
50
40
30
20
10
0
0
0
7
14
19
45
12
29
4
10
1
2
10-19
20-29
30-39
40-49
50-59
60-69
Age of Victims


Employer Type
Total Incidents (N=41)
Source: (NIOSH face data, 1982-1990)
No. of Incidents
Percentage
60
50
40
30
20
10
0
13
32
3
7
4
10
Investor-Owned Utilities
Municipalities
Electric Co-ops
Contractors

Lineworker Electrocutions
Causative Factors
Source: (NIOSH face data, 1982-1990)



growth of the limbs, the victim was not sure which of the limbs was making contact. The density of the limbs also negated the use of the telescopic hot stick. The victim and coworker traveled to a pole-mounted transformer 300 feet away and opened a fused switch on the transformer. The victim thought he had de-energized the 7,200-volt primary line. However, the victim did not ground the primary power line as required by standard operating procedures. The fused switch actually controlled the electrical current to a tap line that provided electrical service for several houses in the area. This tap line was mounted on the same pole as the primary power line. The victim told the coworker that he was going to climb the tree to see if he could correct the situation. Then he reported that the limb was not contacting the power line where he thought. The coworker could not clearly see the victim, but he heard an arcing sound and saw the victim falling to the ground. The coworker ran to the truck and called the company dispatcher to summon the emergency medical squad. He then returned to the victim and initiated cardiopulmonary resuscitation. A second worker in the area heard the call over the truck radio and went to the scene to aid the coworker. The EMS transported the victim to the hospital where he was pronounced dead. Although the event was unwitnessed, electrical burns on the victim's back, torso and limbs suggested the victim lost his balance and fell into the power line. A path for the electric current was established through the victim and the tree to the ground.

The FACE evaluations of line mechanic fatalities identified several common factors in these line mechanic fatalities. These factors are detailed in the graph above. In many of the FACE cases, more than one of these factors were present. The "other" category on the graph represents factors such as improper vehicle maintenance, equipment failure and component failure.

To reduce the incidence of line mechanic fatalities, the following safe work practices and preventive suggestions are presented:

1. All organizations that employ people who work on or close to power lines or any other components of transmission or distribution systems should develop and implement a comprehensive safety program. The program should be designed to help workers recognize, understand and control hazards that they may confront during the performance of their duties. Companies should evaluate each task performed by workers, develop and implement a safety program addressing these hazards, and provide training in safe work procedures.

2. Line mechanic training should include, but not be limited to, instruction in electrical theory, safe work practices, pre-job planning, operation of aerial equipment (bucket trucks, derrick trucks, etc.), the use of personal and electrical protective equipment, use of voltage detection devices, and lockout/tagout procedures for de-energizing, grounding, and testing power lines and equipment. Line mechanics should receive task-specific training that correlates steps in the task with control of the identified hazards. A line me-

chanic should be required to demonstrate proficiency in performing line mechanic duties before being allowed to work on energized or de-energized power lines.

3. All persons performing work on or in the vicinity of unverified de-energized power lines should treat all power lines as hot unless they positively know these lines are properly de-energized, grounded and have been tested. If a line is not grounded, it is not de-energized. If work is being performed on a multiphase system, grounds must be placed on all lines. Lines should be grounded within the sight of the working area and work should be performed between the grounds whenever possible. If work is to be performed out of sight of the point where the line has been de-energized, an additional ground should be placed on all lines on the source side of the work area. Because of the possibility of a feedback circuit, the person performing the work should personally de-energize, ground, and test all lines on both sides of the work area unless he or she is wearing the proper protective equipment.

4. Procedures should be established to perform a dual voltage check on the grounded load and supply sides of open circuits. Once it is determined that high voltage is not present, low voltage testing equipment, such as a glowing neon light or a light-emitting diode, should be used to determine if lower voltages are present.

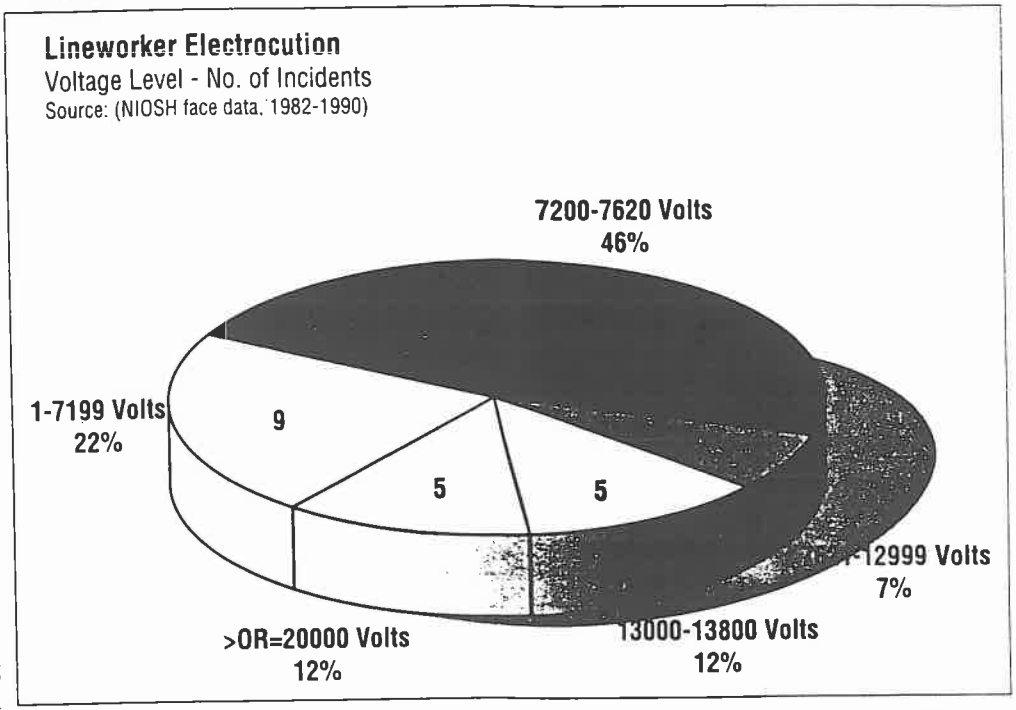
5. Before beginning any work on an electrical system, all workers involved should be aware of the function of each component in the system, and of any hazards created by the functioning of these components. Additionally, workers should be instructed that if any questions regarding the electrical system arise, qualified personnel should be contacted to answer these questions before work proceeds.

6. All installation and maintenance work performed by line mechanics should comply with the safety rules for the installation and maintenance of overhead and underground electric supply and communication lines as outlined in Sections 2 and 3 of the National Electrical Safety Code (ANSI 1990) and any applicable sections of existing standards from the Occupational Safety and Health Administration.

7. Line mechanics should be trained in and instructed to adhere constantly to all established safe work procedures relevant to their duties and responsibilities. Management should periodically conduct random site visits to ensure work crews are following established safe work procedures.

8. Power lines should not be prepared or otherwise accessed without adequate personal protective equipment unless the line mechanic personally verifies that the line is de-energized and properly grounded. Line mechanics must be provided with and specifically instructed to wear all required proper personal protective equipment, such as gloves and sleeves, for the specific tasks to be performed.

9. Qualified personnel should conduct a comprehensive inspection of each worksite prior to the start of each job to identify all potential hazards at the worksite, including any damaged equipment. Then measures should be implemented to control these hazards. The specific tasks to be performed by each worker at the site should be clearly defined at this time. Damaged equipment must either be repaired to manufacturer's specifications or replaced.



10. All personnel working on or in the vicinity of high voltage power lines should be certified in CPR.

As part of the FACE program, the Division of Safety Research investigated 41 line mechanic electrocution events resulting in 43 fatalities. Circumstances surrounding these events have been analyzed and indicate that many events could have been prevented if existing regulatory and consensus standards and known safe work procedures had been followed. These data indicate that although many organizations had comprehensive safety programs, they were not fully implemented. This underscores the need for utilities to increase management and worker understanding and awareness of the hazards associated with working on or in proximity to high-voltage power lines or other components of transmission and distribution systems. In some cases, this may entail the development of additional training, the evaluation and restructuring of existing safety programs or both. Companies, unions and trade associations should work together to recognize the dangers associated with working on or near high-voltage transmission and distribution systems, and to work toward preventing these deaths by implementing appropriate control measures. ❑

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Presence of Stable Coal Radicals in Autopsied Coal Miners' Lungs and Its Possible Correlation to Coal Workers' Pneumoconiosis

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ABSTRACT. Stable coal radicals (SCRs) were detected by electron spin resonance (ESR) spectroscopy in the lung tissue of autopsied coal miners. The SCR concentrations were measured in the lung tissues from 98 coal miners with and without (a) coal workers' pneumoconiosis (CWP), (b) cancer, and (c) a history of cigarette smoking. Concentrations of SCRs were also determined in the lungs of nonminer controls. The SCR concentration was related to longer mining tenure, CWP disease severity, lung cancer, and cigarette smoking. The mean concentration of SCRs in the lung tissues of miners with 30 $\pm$ 1.4 y of coal mining exposure was 5.3 $\pm$ 1.3 $\times$ 10^{17} spins/g versus controls who had a nondetectable level (< 10^{15} spins/g). An increase in disease severity was accompanied by a progressive increase in SCR concentration. A SCR concentration of 4.8 $\pm$ 0.7 $\times$ 10^{17} spins/g was found for simple CWP (with moderate coal macules) versus 7.8 $\pm$ 4.6 spins/g lung tissue for complicated CWP (with progressive massive fibrosis). Significantly higher (i.e., 10 $\times$ 10^{17}) concentrations of SCR in the coal miners' lung tissues were associated with an exposure history in the anthracite regions of northeastern Pennsylvania. These results indicate a possible role for SCRs in the disease process. Furthermore, ESR appears to be an adequate methodology for the quantitation of coal dust retained in the lung and for distinguishing exposures to anthracite and/or bituminous coal.

THE PREVALENCE AND SEVERITY of coal workers' pneumoconiosis (CWP) differ markedly between geographic locations, mines, and coal fields irrespective of comparable levels of exposure to coal mine dust.[1,2] These differences cannot be fully explained by the presence of silica and other minerals in the coal mine

dust.[3] Rank of coal is also an important factor in the pathogenesis of CWP. Equally important is that the prevalence of CWP decreases from east to west in the United States,[4] and South Wales miners develop more severe CWP than miners in Scotland.[5] However, there are conflicting reports that cast uncertainty on the influence of rank of coal in the development of CWP.[6-9] These problems are complicated but will be solved as new technology emerges and as more is learned about the disease process.

As new ideas regarding the pathogenesis of CWP have emerged, we and other investigators have reported the presence and generation of free radicals during crushing and grinding of coal.[10-14] Grinding and crushing operations are involved in coal mining; therefore, it has been postulated that the reactive free radicals generated during coal mining may play a role in the early biochemical injury leading to CWP.[10,12] In particular, we have shown that the concentrations of reactive free radical sites generated during the grinding of coal decrease with time and that there is a concurrent decrease in toxicity as evidenced by hemolysis.[10,11] However, a high concentration of stable coal radicals (SCRs) that had chemical characteristics similar to those generated by the grinding remained detectable in the coal for long periods thereafter.[10] The present study was undertaken to determine possible relationships between severity of CWP and concentration of SCRs and the relationship between cigarette smoking and SCR concentration in the lungs of miners who did and who did not have lung cancer. The presence of SCRs in the lung tissue of autopsied coal miners[10,11,15] and stable radicals in the lungs of urban dwellers[16] has been reported previously. However, this is the first study in which an attempt was made to correlate the concentration of SCRs present in the lung tissue with CWP disease pattern, severity of CWP, cancer of the lung, smoking, and type of coal exposure.

Materials and methods

Coal miners. Lung tissues from 98 coal miners were obtained from the National Coal Workers' Autopsy Study (NCWAS). These tissues were submitted to the National Institute for Occupational Safety and Health (NIOSH) from 1971 through 1980. Only deceased coal miners who had at least 1 y of underground exposure to coal mining were included in the program, and each case was submitted with detailed demographic, occupational, and smoking histories. An autopsy report and lung tissues were submitted for each case. The pulmonary tissues included a minimum of three paraffin blocks and slides from representative sites of the lungs. The relationship between CWP severity, age, mining tenure, and SCRs in the lung tissue was determined from 98 coal miners' autopsy cases that were selected from a subpopulation of 106 primary lung cancer cases. These cases were matched with an equal number of coal miners who (a) did not have lung cancer for age at death (± 2), (b) years of underground coal mining (± 2), and (c) pack-years of smoking (± 2). Among these 98 autopsies, 49 cases had primary lung cancer, 5 had non-lung cancer, and 30 deaths resulted from cardiac diseases. The remaining 14 deaths were caused by pneumoconiosis (n = 4), accidents (n = 3), pneumonia (n = 2), and other diseases (n = 5). Ages ranged from 48 to 84 y in the combined study population, and underground coal mining exposure ranged from 1 to 55 y. Smokers in the group had a smoking history of 1–134 pack-years.

Non-coal miner controls. Lung tissues from 11 autopsied non-coal miners were obtained by matching age at death and sex with coal miners from a local hospital. The medical files of these 11 referent non-coal miner controls were screened to ensure that there was no known history of employment in coal mining or occupational exposure to coal. The information on the smoking habits of these referent controls was unsatisfactory.

Animal controls. Lung tissue samples from pathogen-free Fisher 344 rats that were exposed only to coal dust (2 mg/m³) or filtered air for 7 h/d for 5 d/wk for 24 mo were obtained from an ongoing independent study at NIOSH.[17] These samples were compared with human tissue and human data on SCR concentration. Subsequent to the termination of the 24-mo exposure, the histopathologic evaluation of the lungs demonstrated that coal dust particles were deposited in the lungs and that macules had developed.

Electron spin resonance (ESR). All tissue samples were prepared from paraffin blocks, and the same protocols were employed for electron spin resonance studies. Paraffin sections (20–30 μ) were cut and deparaffinized in three changes of xylene for 1 h and air dried for 24 h at room temperature (22 °C ± 2 °C). Air-dried samples that had an average weight of 20–25 mg were packed in duplicate ESR quartz tubes and were labeled. Duplicate samples from the lungs that were obtained from subjects who experienced an increased severity of disease showed 40–64% variability in the SCR concentration. Samples of lungs from subjects who had minimal disease showed less than 20% variability between samples. Tissue sections were sometimes pooled from two or more paraffin blocks from the same case if the subject had minimal disease and cancer of the lung. The samples were randomized, and SCR concentration was measured with a Bruker ER 200D, X-band (9.5 GHz) ESR spectrometer by two of the authors (ND and BJ) who did not have prior knowledge of case history, smoking history, or disease status of the cases. The SCR concentration for each sample was obtained from the ESR signal intensity, i.e., area under the ESR peaks, via a double integration technique for which an ASPECT 2000 microcomputer was used. The SCR concentration was expressed in spins per gram dry lung tissue.[10,11] The SCR concentration in the air-exposed rat lungs, which were fixed and processed by employing the same protocol, was undetectable. Therefore, no significant effects of processing were apparent.

Spectral differences and similarities between SCR and fracture-induced free radicals were compared. Anthracite (95% carbon) and bituminous (72% carbon) coals

were obtained from the Pennsylvania State University, Generic Respirable Dust Technology Center, State College, Pennsylvania. Coals were hand ground in an agate mortar with pestle for 30 min and sieved to 20-μ size. Comparisons of lung tissue SCRs for which freshly ground and aged coal mine dust were used were made according to the methods reported earlier.[10,11]

Histopathologic analysis. At least three hematoxylin- and eosin-stained sections were available for all cases and controls. In addition, sections stained with special stains were used in the typing and classification of lung tumors. The presence, type, and severity of CWP was evaluated independently and without any prior knowledge of historical information by two pathologists (FHYG and VV), who adhered to the criteria and standards recommended by the College of American Pathologists and NIOSH.[18] Lung cancer was typed and classified according to the World Health Organization criteria.[19]

Statistical analysis. The relationship between SCR concentration in the lung tissue and its possible association with disease processes and smoking was evaluated by controlling the influence of confounding variables. Concentrations of SCRs in tissues showed extreme non-normal variations from case-to-case. To determine the effects of age, years of mining, pack-years of cigarettes smoked, severity of CWP, and lung cancer on SCR concentrations, we first calculated the cube root of the log (SCR $\pm$ 1). This variable had a fairly normal-shaped distribution and was used only for the testing of the hypothesis. The values presented in Tables 1-5 represent SCR data. Each of the independent variables (i.e., age, years of mining, pack-years of cigarettes smoked, severity of CWP, cancer) was then tested separately, either by analysis of variance or by simple linear regression, for its influence on the transformed variable. Variables were excluded from further analysis if a p value greater than .10 was found. The remaining variables and cancer by severity of CWP interaction were then tested simultaneously. If the p value was less than or equal to .05, an effect was considered to be significant.

Results

The 98 coal miners in the study group had an average age of 64 $\pm$ 0.8 y (mean $\pm$ standard error of the mean) and an average underground mining exposure of 30 $\pm$ 1.4 y. Among these 98 coal miners, 18 were nonsmokers. The average pack-years of those individuals who had smoked was 35 $\pm$ 2.9.

Lung tissues from autopsied coal miners were grouped into those without disease (n = 35), macular disease (n = 31), CWP and silicosis (n = 10), and progressive massive fibrosis (PMF) (n = 22). This grouping was based on the highest category of disease type and its severity; hence, subjects with PMF may also have had silicosis, nodules, and macules, and subjects with silicosis may also have had nodules and macules, whereas the subjects grouped under macular disease only had macules.

The mean age, mining tenure, and the SCRs, ranked by disease group, for the 98 coal miners and 11 controls who had no coal mining experience are shown in Table 1. It is evident that in the 11 controls with no known exposure to coal mine dust, there were no SCRs detected in the lung tissue. However, in 35 miners who did not have CWP and who were exposed to varying amounts of coal dust, the mean SCR concentration was $(1.6 \pm 0.7) \times 10^{17}$ spins/g dry lung, whereas in 63 miners who had CWP and who were exposed to a greater amount of coal dust, the SCR concentration was increased approximately fivefold, i.e., $(7.3 \pm 2.0) \times 10^{17}$ spins/g dry lung. In comparison, accumulations of focal black pigmented alveolar macrophages adjacent to the respiratory bronchioles were found in the lungs from rats exposed for 24 mo to 2 mg/m^3 coal dust for 5 d/wk, 7 h/d, and a mean SCR concentration of 0.6×10^{17} spins/g dry lung was found. This was approximately one-half the concentration of SCRs observed in the lungs from miners that showed no evidence of CWP (Table 1). It is interesting that the SCR concentration in autopsied lungs, obtained from urban Tokyo dwellers, with black dust deposits was of the same order of magnitude as that found in rats that were exposed to coal dust for 24 mo.[16] The combined group with CWP showed a fivefold increase in SCR concentration com-

Table 1.—SCR Concentrations in the Lungs of Coal Miners, by Type of CWP

Group	Age	Mining years	SRC conc. 10^{17} spins/g dry lung
Controls (11)	65 ± 1.5†	0 ± 0.0	0.0 ± 0
Miners without CWP (35)	63 ± 1.2	29 ± 2.3	1.6 ± 0.7
All miners (98)	64 ± 0.8	30‡ ± 1.4	5.3 ± 1.3
Miners with CWP (63)	64 ± 1.1	30 ± 1.8	7.3 ± 2.0
Macular CWP (31)	62 ± 1.5	27 ± 2.6	4.8§ ± 1.7
PMF (22)	68 ± 1.8	33 ± 3.3	7.8§ ± 4.6
Silicosis with CWP (10)	64 ± 1.6	34 ± 3.3	14.2// ± 5.2

*Numbers within parentheses indicate number of subjects studied.
†Standard error of the mean.
‡Sample size = 97.
§Different from mean for miners without CWP group, $p < .05$.
//Different from mean for miners without CWP group, $p < .01$.

pared with the group without disease ($p < .01$) (Table 1). Groups with macular CWP and PMF showed higher concentrations of SCRs ($p < .05$) compared with the group without CWP. The group with silicosis and CWP showed a ninefold increase in SCR concentration compared with the group without CWP ($p < .01$).

Typical ESR spectra obtained from dry lung tissues from an autopsied nonminer control, coal miner with macular CWP, coal miner with PMF, and coal miner with macular CWP and silicosis are illustrated in Figure 1 a–d, respectively. The SCR concentration (as can be deduced from the areas under the ESR spectra) was the least for macular disease and the highest for the coal miner with macular CWP and silicosis (Fig. 1). The SCR concentrations for all the samples were calculated by area measurements, which were obtained by a double integration technique completed with the aid of an ASPECT 2000 microcomputer.[10]

After other factors were adjusted form, pack-years of cigarettes smoked and the presence of lung cancer were significantly related to SCR concentration. Age was not related to SCR concentration. Years of mining were related to SCR concentration only when other factors were not adjusted for. The significance of the relationship between CWP and SCR concentration was dependent on the smoking status and the presence or absence of cancer in the lung. The mean SCR concentration in miners who did and did not have lung cancer, by category of pneumoconiosis when pack-years of smoking was controlled for, is shown in Table 2. A strong relationship between SCR and severity of CWP was apparent only for subjects without cancer. Generally, lung cancer cases had lower SCR concentrations than did noncancer cases who had similar CWP. It is not apparent from the preliminary analysis of data on lung cancer cases whether the different cell types had any significant effect on the SCR concentration.

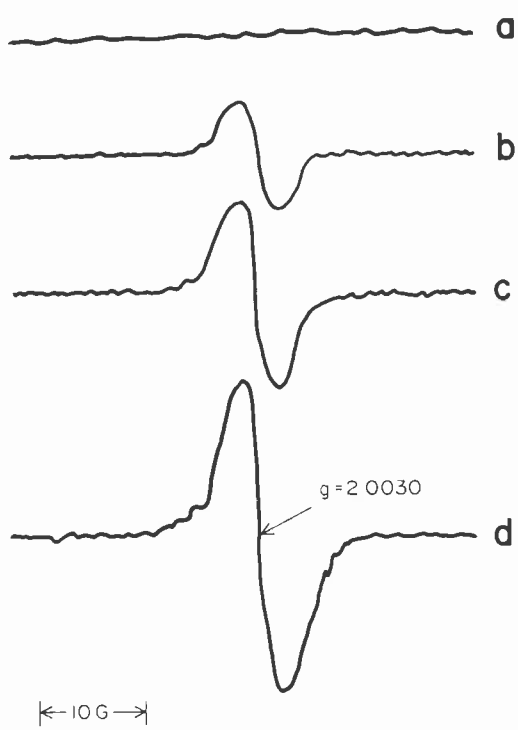

Fig. 1. Typical X-band (9.5 GHz) ESR spectra of air-dried lung tissue samples (25 mg) from (a) control, 72-y-old man, nonminer; (b) 84-y-old man, with 7 y underground coal mining exposure, who had macular lesions; (c) 64-y-old man with 34 y underground coal mining exposure who had macules and PMF; and (d) 58-y-old man with 38 y underground coal mining exposure who had macules and silicosis. The g value was 2.0029 + 0.0005. The magnetic field scale was similar in all measurements.

Table 2.—SCR Concentrations in the Lungs of Coal Miners Who Did and Did Not Have Lung Cancer, Adjusted for Smoking Pack-Years

CWP type	SCR concentration 10^{17} spins/g dry lung* Without cancer	With lung cancer
Without CWP	9.0 ± 0.3 (17)	0.3 ± 0.1 (18)
Macular	0.8 ± 0.3 (13)	1.0† ± 0.3 (16)
CWP with silicosis	3.1‡ ± 1.5 (9)	— (0)
PMF	7.1§ ± 5.8 (5)	0.6 ± 0.2 (14)

*Numbers within parentheses indicate number of subjects studied. Means represent inverse transformation of adjusted means, and standard errors represent one-half the width of the confidence interval of the mean, which was formed by taking the inverse transformation of the 67% confidence intervals endprints of the transformed data.
†Higher than the mean for no CWP group, $p < .05$.
‡Higher than the mean for no CWP and macular groups, $p < .05$.
§Higher than the mean for no CWP and macular groups, $p < .01$.

Table 3.—SCR Concentration in the Lungs of Smokers and Nonsmokers

Group	Age	Mining	SRC conc. 10^{17} spins/g dry lung
Nonsmokers (18)*	66 ± 2†	37‡ ± 2	11.7 ± 3.8
Smokers (79)	63 ± 1	28 ± 2	3.9§ ± 1.4

*Numbers within parentheses indicate number of subjects studied.
†Standard error of the mean.
‡Sample size = 17.
§Lower than mean for nonsmokers, $p < .01$.

The relationship of smoking status with SCR concentration in the lung of coal miners is shown in Table 3. The smokers in the study group showed a threefold decrease in SCR concentration ($p < .01$). This decrease was also clearly evident on a dose-dependent basis, as illustrated in Figure 2, which represents the least squares curvilinear relationship between SCR and pack-years unadjusted for other factors (SCR = Exp $[.977 - .0040PY]^3 - 1$). Smoking appeared to be associated with a decrease in the concentration of SCR.

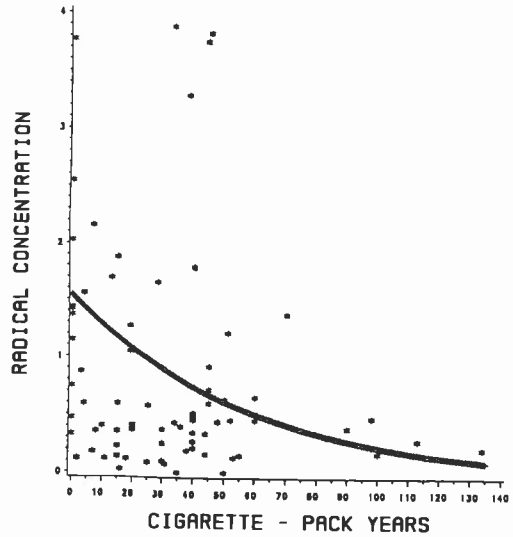

Fig. 2. Effect of cigarette smoking on the concentration of coal stable radicals in lung tissue. The concentration of stable radical decreased on a dose-dependent basis at a statistically significant level ($p < .01$). The estimated dose-response equation was ESR = exp [.97732 - .00396681(*PY*)]^3 − 1.

The decrease in SCR concentration, when adjusted for the influence of other factors (i.e., cancer, CWP severity, and cancer by disease severity interaction), was approximately 0.0024 units in the transformed variable for each pack-year of cigarettes smoked, compared with .004 before adjustment.

The data analysis provided evidence that the smokers had lower levels of SCR and that they tended to experience a lower prevalence of CWP. A higher prevalence of CWP in nonsmokers and a higher SCR concentration are reported in Table 4 ($p < .001$). We sought to confirm this by matching 17 nonsmokers with 17 smokers with respect to age and years of mining tenure, and we compared the prevalence of CWP by type and severity. The mean age of nonsmokers was 66.4 y, and the mean tenure in mining was 36.9 y versus 66.7 y and 36.9 y, respectively, for smokers. A higher prevalence of each CWP disease category in nonsmokers and an overall higher SCR concentration were found in these age-matched analyses ($p < .003$, Table 5).

Discussion

The major hypothesis in this study was that the concentration of SCRs in lung tissue would be related to the severity of CWP. It is evident from the data presented in Table 1 that this was the case. As previously discussed, there appeared to be a direct relationship between the formation of free radicals at the freshly fractured surfaces and the concentration of long-lived SCRs[10,11]; and between rank of coal, free radical formation, and cytotoxicity.[10] Hence, our data suggest indirectly that the fracture-induced free radicals might be involved in the initiation of CWP but that the SCRs contained within the particle may be involved in the propagation of cytotoxic reactions and the progression of CWP. It is known that severity of CWP correlates with total lung dust burden.[3] Therefore, it is probable that SCR in the lung tissue will increase as dust levels increase. The analysis of data showed an exposure-tenure-dependent and disease-severity-associated increase in SCR concentration (when other factors were not adjusted for).

In addition to this possible relationship of SCR concentration in the lungs with CWP severity, the lung tissues from coal miners with silicosis had a significantly higher SCR concentration than that found in the PMF cases. This higher SCR concentration was very evident in all the silicosis cases despite their lower coal mine

Table 4.—Comparison of All Nonsmokers and Smokers for the Severity of CWP and SCR Concentrations

	Without disease	Macule	PMF	Silicosis	SCR conc. 10^{17} spins/g dry lung
Nonsmokers	0 (0%)	6 (33%)	6 (33%)	6 (33%)	11.7 ± 3.8
Smokers	35 (44%)	25 (32%)	15 (19%)	4 (5%)	3.9 ± 1.4

Table 5.—Age and Years of Mining Comparison of 17 Nonsmokers and 17 Smokers for the Severity of CWP and SCR Concentration*

	Without disease	Macule	PMF	Silicosis	SCR conc. 10^{17} spins/g dry lung
Nonsmokers (17)	0 (0%)	6 (35%)	5 (29%)	6 (35%)	12.4 ± 16.2
Smokers (17)	8 (47%)	5 (29%)	2 (12%)	2 (12%)	4.2 ± 7.6

*The mean age of nonsmokers was 66.4, and the mean number of years spent mining was 36.9. The mean age for smokers was 66.7, and the mean number of years spent mining was 36.9.

dust burden present in the lung sections, compared with PMF cases. Aged silica does not contain SCRs as does aged coal[11]; therefore, we conjectured that this increased concentration of SCRs in silicosis may have resulted from a high concentration of anthracite coal in the lung. Earlier observations[10,11] from this laboratory and by others[12] indicated that higher concentrations of SCRs are present in the anthracite coal and that fracturing generated significantly greater concentrations of free radicals from anthracite coal than from bituminous coal.[11] Electron spin resonance spectral shapes and signal intensities noted for the lung tissues obtained from subjects with silicosis were comparable to anthracite coal samples that had 95% carbon content, which indicated that there was a relationship between anthracite coal mine exposure and a higher concentration of SCR in lungs. Support for this hypothesis was obtained from the observation that all the silicosis cases in this study had worked in the northeastern and north central coal mines of Pennsylvania. A high prevalence of pneumoconiosis and silicosis in the anthracite miners of northeastern Pennsylvania[20,21] have been documented in epidemiologic and pathologic studies. Because there were a limited number of silicosis cases in our study, we did not attempt to further breakdown these analyses to detect differences between specific mines or coal seams. Also interesting is that all the cases (16/96) with a relative SCR concentration greater than 10×10^{17} spins/g dry lung had work histories in northern and north central Pennsylvania coal mines, which indicated a relationship between higher SCR concentration and anthracite coal mine dust exposure.

The SCR concentration in the lungs of miners showed a progressive increase proportional to the length of coal mining tenure and disease severity, but lung tissues of miners who had a history of smoking cigarettes had significantly lower SCR concentrations. This decrease in SCR concentration was dose-dependent, and significantly lower SCR concentrations were observed in the lungs from miners who smoked heavily ($p < .01$). However, this lower SCR concentration was also very evident in lung cancer cases adjusted for pack-years of smoking. The miners who had lung cancer and who did not have CWP and miners who had lung cancer and who did not have PMF had lower concentrations of SCRs than did those who did not have lung cancer. Therefore, it appears that this lower SCR concentration in lung cancer cases is not entirely the result of smoking and may be influenced by lung cancer and other factors.

Although the data in Table 5 would appear to indicate that smoking and cancer protect against CWP, we maintain this is not the case. Given the data on SCRs for smokers and nonsmokers in this study, several factors should be considered before the interpretations can be generalized to the entire population. A reasonable explanation of the relationship between SCR concentrations and both smoking and lung cancer involves the biased nature of this autopsy population. The lung tissues submitted to the NCWAS from nonsmoking coal miners were from coal miners who probably died of CWP and, therefore, whose lung tissue had high SCR values. However, smokers submitted to the NCWAS may have died prematurely from cancer of the lung or from heart disease rather than from CWP; they would have had a reduced mining tenure and low SCR values. Another possibility is that the NCWAS population may have been biased because it included only a small proportion of all miners who died with an exposure history in coal mines. Available estimates based on expected death rates of retired and active coal miners for the years 1970 to 1980 indicated that less than 10% of the coal miners' deaths were reported and submitted to the NCWAS program. It is possible that, because this was not a random sample, the majority of miners submitted to the NCWAS program had less CWP and were more severely affected by smoking-related diseases (e.g., cancer, emphysema, bronchitis). Therefore, the lower SCR concentrations observed in the smokers may have resulted from this biased sample of smokers who had minimal CWP. In support of this hypothesis, we found a significant decrease in the SCR concentration and prevalence of overall CWP in 17 smokers, compared with nonsmokers matched for age and years of mining. Comparison of all the smokers and nonsmokers in the study group also produced a chi-square significance of $p < .001$ for less CWP in smokers who had lower SCR concentrations.

Consideration of other independent contributions to the possible increase or decrease in SCR concentration may also be important. Among these, smoking, cancer, anthracite exposure, and other interactions of biomolecules should be considered. It is possible that increased mobility of macrophages, clearance, destruction of lung tissue, obstructive airways or hypersecretion of sputum that causes the deposition of inhaled dust in the bronchi and prevents its deposition deep in the alveoli might impact SCR concentration. Furthermore, it is possible that the lower SCR concentration in smokers may have resulted from the radical interactions or quenching effect of some chemical species present in the cigarette smoke. In support of this view, it was shown recently that cigarette smoke contained many short-lived highly reactive free radicals.[22] Such radicals could quench the SCRs via radical-radical termination reactions.

Other alternate mechanisms might be postulated to have caused a decrease or increase in SCRs in smokers and nonsmokers. A possible relationship of anthracite coal mine exposure and increased SCR concentration could be conjectured from the fact that all the coal miners in this study with a SCR concentration greater than 10×10^{17} spins/g dry lung had a work exposure in the coal mines of northeastern or north central Pennsylvania. We have shown previously that the free radical concentration of freshly ground anthracite coal is approximately 300% more than that of bituminous coal.[11] We also determined that the ESR spectral width and line intensities of the 18 cases with SCR concentrations above 10×10^{17} spins/g dry lung weight were comparable to either anthracite coal mine dust or a mixture of anthracite and bituminous coal, which indicated mixed exposures.

In conclusion, the ESR results presented in this study

provide evidence for the presence of SCRs embedded in the lung tissue even after years of residence in the lung. Generally, organic radicals such as those generated by fracture of the coal would have short lifetimes. However, their lifetime may be long because they are stabilized within coal because of being entrapped in the particle. Normally such entrapped stable radicals are not expected to react with tissue. Because coal is porous, a possibility of reactivity with these entrapped SCRs cannot be ruled out. In this context, Pryor et al.[23] have recently reported on ESR detection of stable radicals in pyrolyzed perfluoro polymer particles. In agreement with our present results on the SCRs in coal, these authors showed that the radicals in the burned polymer particles are stabilized by entrapment within the particle lattice. Without entrapment, the radicals would be too short-lived to reach the lower respiratory units. The particles act as carriers for radicals. From these studies, Pryor et al.[23] have suggested a combination of particle-mediated and particle-associated radical-mediated damage as the cause of the unusual toxicity of perfluoro polymer smoke.[23] Our data and the conclusions of the present study concur with this suggestion, which indicates that the entrapped SCRs might indeed be involved in the biochemical reactions of coal that lead to lung injury.

Finally, the ESR methodology can be used to provide quantitative measurements of coal dust load and to distinguish between anthracite and bituminous coal mine exposures.

* * * * * * * * * *

This study represents a collaborative effort between NIOSH and West Virginia University. The University's contribution was supported by Grant No. G1135142 from the Bureau of Mines through the Generic Technology Center for Respirable Dust.

Submitted for publication July 11, 1990; revised; accepted for publication April 16, 1991.

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Agricultural Machine-Related Deaths

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ABSTRACT

Analysis of 1980-1985 death certificate data for the United States indicated that an average of 369 occupational deaths per year involved agricultural machinery as the external cause of death. Out of all agricultural machine-related deaths, tractors accounted for 69 percent. Over half of these tractor-related deaths were rollovers. There is a need for public health programs to affect greater use of rollover protective structures (ROPS) on farm tractors. (*Am J Public Health.* 1991;81:766–768)

Introduction

Fatalities among farm machine operators present a conspicuous injury target for public health action.[1–3] Farm tractors are known to be particularly deadly,[4–6] but prevention programs appear to be floundering.

As a first step toward the establishment of priorities for fatality prevention programs in agriculture, we decided to examine the National Traumatic Occupational Fatality (NTOF) data base maintained by the National Institute for Occupational Safety and Health (NIOSH).[7,8] Previous analysis of NTOF data for the years 1980-85 had shown that the Agriculture, Forestry, and Fishing industry had a fatality rate of 20.7 per 100,000 workers, a rate 2.6 times higher than the national average for all industries of 7.9 deaths per 100,000 workers.[7]

Methods

Death certificate data in NTOF were reviewed to identify persons killed while working with machines. Machine-related fatalities were identified by codes E919.0 to E919.9 according to ICD-9. Next, the type of machine involved in each machine-related fatality across all United States industries was ascertained by reviewing the description of the cause of death on the death certificate. All agricultural tractor-related fatalities were then categorized and compared by the Standard Industrial Classification (SIC) for the industry in which the incident occurred.[9] Age at death was determined for those fatalities associated with tractors, augers, hay balers, combines, and other agricultural machines.

TABLE 1—Machine-related Occupational Fatalities, All US Industries, 1980–85

Machine Type	Frequency*	Percent of Fatalities
Agricultural machines, E919.0	2216	43.8
Lifting machines, E919.2	1029	20.3
Mining, earth drilling machines, E919.1	467	9.2
Earthmoving, excavating machinery, E919.7	458	9.0
Other specified machinery, E919.8	441	8.7
Unspecified machinery, E919.9	237	4.7
Metalworking machinery, E919.3	88	1.7
Transmission machinery, E919.6	78	1.5
Woodworking machinery, E919.4	47	0.9
Total	5061	99.8**

*Values are based on the 90.6 percent of case records in the NTOF data file that have ICD codes.
**Sum differs from 100 due to rounding.

TABLE 2—Frequency of Agricultural Machine-Related Fatalities (E919.0), All US Industries, 1980–85

Agricultural Machine	Fatalities	Percent
Tractor	1523	69
Auger/elevator	61	3
Combine	53	2
Hay Baler	42	2
Brush hog/mower	40	2
Loader/skidder	37	2
Corn picker	26	1
27 other machines	108	5
Unspecified machine	326	15
Total	2216	101

*Sum differs from 100 due to rounding.

Results

The search of NTOF cases identified 5,061 machine-related fatalities coded E 919.0 to 919.9 (Table 1). Agricultural machines were involved in 2,216 deaths, an annual average of 369 deaths per year. The second ranking machine category on the list is lifting machines (cranes, forklifts, etc.) which averaged 170 fatalities annually, less than half that of agricultural machines.

The seven types of agricultural machines with greatest fatality frequency are listed individually in Table 2. Machines with a frequency less than 1 percent were combined into one category. The final category includes fatalities in which the type of machine was not specified on the death certificate. These data indicate that tractors are involved in the vast majority of agricultural machine-related fatalities. All other agricultural machines are involved in far fewer fatalities when compared to tractors.

Tractor overturns were the single most important event in fatalities involving tractor operators. Of the tractor-related fatalities in the NTOF data set, 52 percent were rollovers. Another 16 percent involved the victim being run over, such as instances in which an operator fell off the tractor and was run over. About 7 percent of the tractor-related fatalities were associated with the power-takeoff.

Farm tractors are used in many industries. For example, using farm tractors to pull cut timber in logging operations is considered to be a manufacturing industry activity. Of farm tractor-related fatalities, 59.3 percent occurred in the agriculture, forestry, and fishing industry, while manufacturing, services, and construction industries each contributed over 5 percent to the national death toll. Victims over 50 years old accounted for 62 percent of farm tractor-related fatalities, and victims over age 60 accounted for 44 percent of farm tractor-related fatalities.

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Discussion

The findings reported here are similar to those reported in studies of farm fatalities in Wisconson[5] and Georgia.[6] All of these investigations found that tractor overturns accounted for the largest proportion of farm deaths (Wisconsin 52 percent; Georgia 76 percent; US 52 percent.)

Education, enforcement, and engineering control are often cited as the avenues for prevention of occupational injuries and fatalities. The mandatory education approach to farm tractor safety has not yet received sufficient emphasis. Some training is available through voluntary organizations such as the 4-H and Future Farmers of America. However such training is voluntary. It is unnecessary to pass a test, as is the case with obtaining a license to operate a motor vehicle, unless the tractor driver is age 14–16 and employed by someone not in the family.[10] For all other farm tractor drivers, no license of any kind is required. Furthermore there is no competency-based certification program for tractor operators.

The enforcement approach also has problems. In its annual appropriations bills for the Occupational Safety and Health Administration (OSHA) in the US Department of Labor, Congress has consistently attached a rider which denies OSHA the authority to inspect farms with fewer than 11 employees. This exempts 89 percent of US farms which may choose to comply or not comply with federal safety standards, free of an OSHA inspection. Unlike some consumer products, which may not be sold in the US if they do not meet regulations of the Consumer Product Safety Commission, the sale of farm machinery is not regulated for safety. Because most farm workers are not covered by OSHA enforcement, regulating farm machine safety at the point of sale has been suggested as a promising way to protect farm workers from machine hazards.

The engineering approach involves efforts at preventing rollovers, as well as protecting operators if a rollover does occur by fitting tractors with rollover protective structures (ROPS). Much effort has already gone into the design of ROPS for tractors, and industry-accepted voluntary standards call for the provision of ROPS on new tractors. OSHA has a requirement that employers must have ROPS on new tractors built since October 25, 1976. One of the difficulties encountered in this approach is the fact that farm tractors tend to be used for so many years that replacement of older tractors with newer, safer tractors is proceeding very slowly. There is also a problem with some farmers removing ROPS from new tractors. Considering all these factors, during the next 10 or 20 years it is unlikely that the percentage of tractors with ROPS will increase rapidly unless some significant changes take place. Although engineering has provided the technology for preventing most fatalities due to tractor rollovers, it appears that voluntary implementation is very slow.

In Sweden a very significant reduction in tractor rollover fatalities has been brought about by requiring rollover protection on farm tractors.[11] Between 1961 and 1983, Sweden was able to drop its annual fatality rate for tractor overturning from 12 per 100,000 farmers to 1 per 100,000 farmers. This was accomplished through regulations introduced periodically between 1959 and 1981.

It will take cooperative action, including input from farmers, to develop creative prevention programs to solve this difficult problem. Education, enforcement, and engineering will work if they are supported by the common interest of a united agricultural public health community. Achieving this unity is a crucial goal for the 1990s. □

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Clinical Note

Fumigant Intoxication during Transport of Grain by Railroad

We would like to report what appears to be a previously unreported source of worker exposure to fumigants. In May of 1989, three federal grain inspectors with the US Department of Agriculture in Portland, Oregon, were exposed to phosphine while inspecting wheat on an unplacarded railroad train. One worker, the "grain sampler," opened the top hatch on the first car in the shipment and immediately noted a gray deposit on the grain and a garlicky smell. The worker recognized this as the appearance and smell of aluminum phosphide. A second worker collected grain samples for grading by reaching into the hopper cars, while the first worker continued opening cars. Similar evidence of aluminum phosphide residue was noted in subsequent cars, though odors were not consistently perceptible. A third worker arrived to transport the samples to the lab. None of the workers were wearing any respiratory protection.

When the seventh car was opened, there was "an immediate overpowering blast of fumigant odor." There was no skin contact and the hatch was closed very quickly. Almost immediately, the three workers began to develop symptoms; within an hour they were seen at a local emergency room. All three complained of facial numbness and tingling, dizziness, nausea, and shortness of breath. Two of the three complained of headache and disorientation. One worker also complained of diaphoresis, despondency, and a "sense of doom." He reported being closest to the cars when they were opened. He had a history of asthma, a remote 10-pack year use of tobacco, and hypertension. His medications were theophylline 300 mg twice daily; an occasional beta agonist inhaler, chlorthalidone 50 mg daily, and clonidine .1 mg twice daily. He had a similar exposure episode in 1979 to a carbon tetrachloride- and- bisulfide-based fumigant, for which he sought medical treatment.

The other two workers were current smokers and had negative medical histories. Ear, nose and throat, cardiac, pulmonary, gastrointestinal, and neurological exams were unremarkable acutely and on follow-up. All three had negative chest roentgenographs. Arterial blood gases showed no abnormalities. All three workers had urine and blood samples sent for phosphine detection to the Department of Agriculture laboratory. Test results were negative.

The grain in several of the railroad cars in question were sampled after at least 20 minutes of aeration. Car #2 had a phosphine level of 159 ppm, car #5 298 ppm, and car #7 2029 ppm. Aeration of the cars precluded measuring the amount of phosphine in the air pocket within the cars above the grain. Unfortunately, there is no reliable method for measuring levels of phosphine in blood and urine except for high-dose exposures to aluminum phosphide. [Personal communication, Daniel Shaheen, Vice President, Technical Section, Degesch America Incorporated (manufacturer of aluminum phosphide) Weyers Cave, VA].

Case 1 was symptomatic 4 days later and reported for consultation to the Occupational Medicine Clinic at Kaiser Permanente, Clackamas, Oregon. He complained of headache, nausea, shortness of breath, fatigue, and intermittent diaphoresis. The exam remained negative and the complete blood count was normal. Serum SGOT was 33, GGT was 47, BUN 15, and creatinine 1.2. Three weeks later the patient still complained of shortness of breath. The other symptoms had resolved. Pulmonary function testing for case 1 is presented in the Table.

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Partial funding for the case investigation came from a grant through the National Institute for Occupational Safety and Health, Sentinel Event Notification System for Occupational Risk Program (Award #U60-CC4-0-03009-01).

0096-1736/91/3301-0064$03.00/0

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TABLE 1
Pulmonary Function Testing in Case 1 Exposed to Phosphine

Date	FVC (liters)	% predicted	FEV1 (liters)	% predicted
9/83	3.87	84	2.84	80
6/89*	3.65	82	2.57	71
7/89†	3.85	84	2.90	80

* 3 weeks postexposure.
† 7 weeks postexposure.

Case 1 returned to work 12 days postexposure with use of a respirator with a filter effective for fumigants for use while inspecting railroad cars. By 6 weeks postexposure he was asymptomatic.

Case 2 was asymptomatic after 4 days and did not seek follow-up care.

Case 3 followed-up at the Kaiser Permanente Occupational Medicine Clinic 3 months postexposure and complained of episodes of disorientation and daily occipital headaches. Neurological exam remained negative. The electroencephalogram was normal.

Phosphine is a highly toxic fumigant that is widely used against insects and rodents in stored grain.[1] Its use has increased dramatically after changes in regulation limiting the use of liquid fumigants.[2] Aluminum phosphide tablets are placed in the grain, resulting in the production of phosphine gas as moisture is absorbed and hydrolysis occurs.[3] Health effects have been reported to occur at levels below the olfactory threshold of 1.5 to 3 ppm.[4] At perceptible levels, olfactory fatigue may reduce the ability of workers to detect phosphine odor.[2]

These three workers probably received short exposures to air levels of phosphine that exceeded American Conference of Governmental and Industrial Fumigants short term exposure limit of 1 ppm[5] and possibly the level considered to be "Immediately Dangerous to Life or Health" (National Institute of Occupational Safety and Health) of 200 ppm.[6] The product label and federal law specifically require placarding of containers and railroad hopper cars when aluminum phosphide is used for grain fumigation.[7,8]

Two of the persons involved in this incident reported experiencing symptoms in previous grain inspection exposure situations. In the Portland metropolitan area, 25 similar—through less severe—episodes of fumigant exposure have occurred during the last 18 months (personal communication, Walter Rust, Assistant District Manager, Federal Grain Inspection Service, US Department of Agriculture).

These workers' symptoms are similar to those described elsewhere after acute exposure to phosphine.[3,9,10] Symptoms from acute exposure are generally transient and findings are negative on physical examination and laboratory tests.[3,9] The one worker with preexisting asthma had a temporary exacerbation of his bronchospasm. Other reported exposures have been aboard ships[10,11] and in grain elevators.[3,9] Longer exposures have been reported to cause myocardial, liver, urinary tract, and neurological injury.[10]

There is little information on health effects associated with repeated low dose exposures. Exposure to low levels of phosphine has been identified as a potential safety hazard because it increases the risk of exposed workers falling from the top of the rail cars.[12] Our experience suggests that unaerated railroad cars carrying fumigated grain may be an important source of fumigant exposure in addition to those sources already described in the literature. Up to 500 state and federal grain inspectors may be at risk.[10] Their work practices and resultant exposures need to be better characterized to determine the best preventive interventions. Minimum prevention should include better work education about health risks, better enforcement of placarding fumigated shipments, and better use of respiratory protection by grain inspectors opening railway cars.[13]

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Acceptability and Reproducibility Criteria of the American Thoracic Society as Observed in a Sample of the General Population[1,2]

JOHN L. HANKINSON and KI MOON BANG

SUMMARY An analysis of spirograms of 6,486 subjects from the general population, ages 8 to 90, was conducted to determine their ability to satisfy the American Thoracic Society's (ATS) acceptability and reproducibility criteria. The results indicate that both older and younger subjects had more difficulty satisfying the ATS acceptability and reproducibility criteria. The difficulty in satisfying the ATS reproducibility criterion, particularly in younger subjects, was in part associated with their smaller heights and lung volumes. A relatively uniform within-subject variability of FVC and FEV_1 in terms of the mean differences between the largest and second largest FVC and FEV_1, for all heights, was observed. In addition, unlike the ATS reproducibility criterion, when a constant 200-ml reproducibility criterion for FVC and FEV_1 was used, there was no longer a significant difference between the number of reproducibility criterion failures for the 14 different height groups used. These results suggest that the ATS reproducibility criterion, based on a percentage of the FVC and FEV_1, may inappropriately classify a higher percentage of subjects with smaller heights and lung volumes as having a nonreproducible test. In contrast, subjects with larger heights and lung volumes are much less likely to fail the ATS reproducibility requirement. These results emphasize the importance of following the ATS recommendation of using the reproducibility criterion only as a goal during data collection, not to classify a subject as having an invalid test.

AM REV RESPIR DIS 1991; 143:516-521

Introduction

In 1978 the National Institute for Occupational Safety and Health recommended to the Occupational Safety and Health Administration that certain criteria be established for the administration of pulmonary function examinations under provisions of the Cotton Dust Standard (1). These criteria included instrumentation and procedural and technician training requirements. The procedural recommendations included both acceptability and reproducibility criteria for the FVC and FEV_1. Specifically, the reproducibility criterion recommended that the largest FVC and FEV_1 and second largest FVC and FEV_1 be within 10% or 200 ml, whichever is greater. In 1979 the American Thoracic Society (ATS) published Spirometry Recommendations (2), which also included acceptability and reproducibility criteria. In 1987 the ATS published an update to their 1979 recommendation (3), which recommended a reproducibility criterion for the FVC and FEV_1 of 5% or 100 ml, whichever is greater. The ATS also recommended that at least three acceptable curves (no cough, excessively large extrapolated volume, and others) be obtained. One important change in the 1987 ATS update was the clarification that the reproducibility criterion was to be used only as a guide to whether more than three FVC maneuvers were needed. The reproducibility criterion was not to be used for excluding results from reports or for excluding subjects from a study. The rationale for this recommendation was based on several recent studies that have shown that the exclusion of subjects for poor reproducibility may inappropriately exclude subjects who may have a ventilatory abnormality (4–6).

The following analysis was conducted to investigate the ability of members of the general population to satisfactorily complete a spirometric examination, that is, their ability to satisfy the ATS reproducibility criterion as a goal during data collection.

Methods

Spirograms from 6,486 subjects were studied at 25 different locations as part of the National Health and Nutrition Examination Survey III (NHANES III). The NHANES III is the most recent in a series of studies designed to assess the health and nutrition status of adults and children in the United States through interviews and direct physical examinations. The sample design of the NHANES III is a stratified multistage probability sample of the U.S. population. Approximately 40,000 individuals, aged 2 months and older, were randomly selected to participate in the survey (7). The survey has been conducted by the National Center for Health Statistics since September 1988 and will continue approximately 6 yr at 88 locations across the United States. During the first 2 yr of the survey spirometry data have been collected for sample persons aged 8 yr and older in 25 sample areas.

Quality control of the spirometry data has been performed by the National Institute for Occupational Safety and Health (NIOSH), Morgantown, West Virginia, which serves as the quality control center. Each technician received at least 1 wk of formal training, satisfactorily completing a NIOSH-approved course on spirometry. Before the beginning of this study, four pilot studies were conducted (820 subjects; data not included in this analysis), during which the technicians practiced and received additional supervised instruction and monitoring.

Each subject attempted to perform at least five FVC maneuvers, with a goal of meeting the ATS acceptability and reproducibility criteria. For each FVC maneuver only the exhaled volume was accumulated in a dry-rolling seal spirometer. The displacement of the spirometer was measured using a digital shaft encoder and stored in digital memory using

(*Received in original form May 18, 1990 and in revised form September 24, 1990*)

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a dedicated microprocessor. The spirometer system has a volume resolution of approximately 2.6 ml and a sampling interval of 10 ms and has been independently tested (8) and found acceptable with regard to ATS spirometry recommendations. The entire uncorrected volume-time curve (displacement from the digital shaft encoder), up to a maximum of 20 s, was saved on digital tape for each FVC maneuver performed by the subject.

Before each subject began his or her spirometric examination the technician explained and demonstrated the performance of the FVC maneuver. During the performance of the FVC maneuver real-time displays of the flow-volume and volume-time curves, as well as a 6-s exhalation indication, were provided for the technician to monitor the subject's performance. At the completion of each FVC maneuver the computer displayed, for all maneuvers, the flow-volume curves, the calculated parameters of FVC, FEV_1, peak flow, and expiratory time, and the percentage difference between each value of FVC, FEV_1, and peak flow and the corresponding largest value. The computer also determined whether the last curve was acceptable (no cough, excessive extrapolated volume, and late peak flow) and whether additional maneuvers were needed to meet the ATS acceptability and reproducibility criteria. Using these displays and results the technicians modified their coaching to obtain acceptable and reproducible results, usually obtaining a minimum of five and a maximum of eight maneuvers. The technicians were instructed to ensure that subjects produced the highest possible peak flows and that maximal exhalations continued for at least 6 s and until there was no appreciable change in volume (40 ml) for at least 2 s. For Spanish-speaking subjects a Spanish-speaking technician administered the test or an interpreter was provided. Unless there was a valid reason, nose clips were worn and the test was performed in the standing position. A note was made if these procedures could not be followed.

For all but the first few study sites the completed volume-time curves were uploaded at the end of a day's testing to a computer (VAX 11/780) located at quality control center. All spirograms were reviewed by a senior quality control technician, and appropriate follow-up instructions were provided to the technicians. In addition, the technicians were periodically monitored by a senior quality control technician who traveled to the field to observe and provide additional instructions. At the completion of each study at a particular location (25 total), a quality control report evaluating each technician's performance was generated and used to determine whether additional training or monitoring was warranted.

In accordance with ATS (2) guidelines all unacceptable maneuvers (with coughs or extrapolated volumes greater than 5% of the FVC) were excluded before the reproducibility calculations were performed. The technician could also classify curves as unacceptable, and these field classifications were reviewed by a senior technician at the quality control center. The largest FVC and FEV_1 were selected from acceptable maneuvers, regardless of whether they came from the same maneuver. All volumes were reported at BTPS. Subjects with fewer than two acceptable maneuvers (301 subjects) were excluded from further consideration in our reproducibility analysis, and unless otherwise noted all means and percentages were obtained excluding these 301 subjects (N = 6,185). All acceptable curves (no cough or large extrapolated volume) were used in the reproducibility analysis, even if they represented a submaximal effort (low peak flow). Mean differences between the largest FVC and second largest FVC (defined as ΔFVC) and mean differences between the largest FEV_1 and second largest FEV_1 (ΔFEV_1) were calculated for each height group using values of height within ± 5 cm of those shown in figures 3 and 4.

The ATS committee's rationale for using a percentage of FVC and FEV_1 for the reproducibility criterion is presumed to be based on the assumption that the within-subject variability is proportional to lung size. An analysis to determine whether the variability of FVC and FEV_1 (ΔFVC and ΔFEV_1) increases with increasing FVC and FEV_1 should resolve this issue. However, FVC and FEV_1 variabilities have been shown to increase with obstructive lung disease (9). To investigate the effect of lung size on reproducibility, therefore, comparisons were made versus height as a surrogate for lung size under the assumption that respiratory diseases should be independent of height.

The subject's ability to understand and perform the FVC maneuver can also influence the test reproducibility. This may occur in younger and older subjects, who as a group had a higher percentage of unacceptable curves and a higher percentage of abnormal FVC and FEV_1/FVC%. Therefore, a separate analysis was conducted on subjects between the ages of 18 and 55 to reduce these effects.

All statistical analyses were performed on an IBM PC 386 computer using the Statistical Analysis System from the SAS Institute (10). All comparisons of group means were conducted using *t* tests, and tests of independence were conducted using a chi-square test. To investigate other factors that may influence test reproducibility the SAS GLM procedure was used with continuous variables of age, height, percentage of predicted FVC and FEV_1/FVC%, and indicator variables of sex, race, and Hispanic origin. For classification of an abnormal pulmonary function test result each subject's observed FVC and FEV_1/FVC% was compared to his or her predicted values to determine if either were below the lower 95th percentile or lower limit of normal (LLN) of Knudson's (11) reference equations. Predicted FVC for black subjects were adjusted by multiplying the Knudson's value for white subjects by 0.85 (12). The relatively few subjects who were neither white nor black (48), or for whom no ethnic group code was assigned (78), were grouped into the nonwhite category. Subjects of Hispanic origin were grouped into the white group for the white versus nonwhite comparisons.

Results

Of the 6,486 subjects studied 301 (4.6%) subjects had fewer than two acceptable curves and were excluded from the reproducibility analysis, leaving 6,185 subjects. The mean height, number of subjects with two or more acceptable curves, and number of subjects with an FVC or FEV_1/FVC% less than the LLN for eight different age groups are listed in table 1. The subjects older than 55 had a greater tendency to fall below Knudson's (10) 95th percentile or the lower limit of normal for FVC and FEV_1/FVC%, and a slightly lower height.

The results by age group for several measures of the quality of the FVC maneuver are shown in figures 1 (males) and

TABLE 1

MEAN HEIGHT AND NUMBER OF SUBJECTS WITH TWO OR MORE ACCEPTABLE CURVES AND WITH FVC OR FEV_1/FVC% BELOW LOWER LIMIT OF NORMAL FOR TOTAL POPULATION EXAMINED BY AGE GROUPS

Age Groups	Total N	Height		≥ Two Acceptable Curves		FVC < LLN		FEV_1/FVC% < LLN	
		Mean	SEM	N	%	N	%	N	%
8–15	1,087	149.4	0.42	1,052	96.8	14	2.6	10	1.8
16–25	1,155	167.4	0.28	1,128	97.7	15	2.6	25	4.3
26–35	993	167.2	0.30	970	97.7	8	1.5	30	5.6
36–45	868	167.0	0.34	843	97.1	14	2.8	54	10.8
46–55	613	167.6	0.39	590	96.3	7	2.2	39	12.5
56–65	722	165.8	0.36	676	93.6	19	5.1	75	20.0
66–75	591	164.8	0.39	539	91.2	24	8.3	58	20.0
> 75	457	162.8	0.47	387	84.7	38	16.7	57	25.0
Total	6,486	163.6	0.15	6,185	95.4	139	4.1	348	10.3

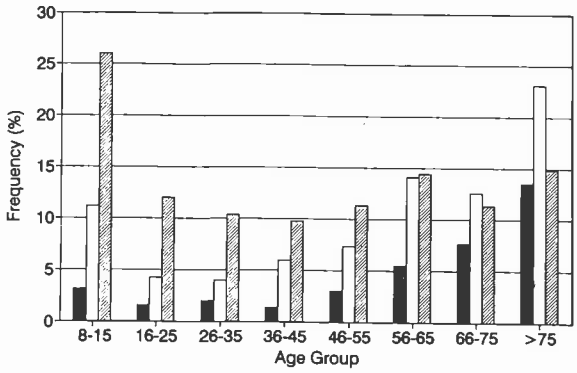

Fig. 1. Percentage of male subjects with fewer than three acceptable curves, nonreproducible test, and more than seven FVC maneuvers by age group (N = 3,119). Solid bars = < 3 acceptable; open bars = nonreproducible; hatched bars = > 7 curves.

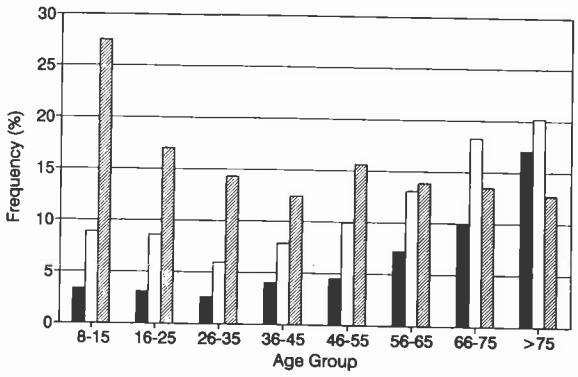

Fig. 2. Percentage of female subjects with fewer than three acceptable curves, nonreproducible test, and more than seven FVC maneuvers by age group (N = 3,367). Solid bars = < 3 acceptable; open bars = nonreproducible; hatched bars = > 7 curves.

2 (females). Both male and female older subjects had more difficulty meeting the ATS recommended reproducibility (largest and second largest FVC and FEV_1 within 5%) and acceptability criteria (at least three acceptable maneuvers). However, it appears that the technician appropriately responded to the lack of a reproducible or acceptable test result by obtaining more maneuvers from these subjects, particularly in the younger subjects. Note the higher percentage of the younger subjects with more than seven FVC maneuvers. During the data collection the technicians reported more difficulty explaining the test procedure to the older subjects and the necessity of obtaining additional maneuvers. For subjects older than 65 yr 55 (45.1%) of those with fewer than three acceptable trials simply declined to perform more than two maneuvers.

TABLE 2

MEAN DIFFERENCES BETWEEN LARGEST FVC AND SECOND LARGEST FVC AND LARGEST FEV_1 AND SECOND LARGEST FEV_1, NUMBER WITH FEWER THAN THREE ACCEPTABLE CURVES, AND NUMBER FAILING ATS REPRODUCIBILITY CRITERION*

Age	Total Number	Study Number	ΔFVC (ml)		ΔFEV_1 (ml)		< Three Acceptable Curves		Non-reproducible	
			Mean	SEM	Mean	SEM	N	%	N	%
8–90										
Males	3,119	3,057	74.8*	1.78	64.5*	1.62	122*	3.9	287†	9.2
Females	3,367	3,274	65.6	1.65	56.3	1.58	179	5.3	348	10.3
18–55										
Males	1,558	1,542	69.9*	2.23	63.8*	2.33	13†	0.8	81*	5.2
Females	1,801	1,766	61.7	2.05	55.0	2.12	27	1.5	140	7.9
8–90										
White	4,593	4,483	76.9*	2.43	65.0*	2.20	221†	4.8	378*	8.2
Nonwhite	1,893	1,848	67.2	1.38	58.3	1.31	80	4.2	257	13.6
18–55										
White	2,297	2,263	59.9*	1.53	54.8*	1.71	59†	2.6	102*	4.4
Nonwhite	1,062	1,045	77.6	3.43	68.4	3.29	32	3.0	119	11.2
8–90										
Hispanic	2,147	2,074	68.4†	2.05	64.4*	2.28	136*	6.3	193†	9.0
Non-Hispanic	4,339	4,257	70.8	1.50	58.2	2.29	165	3.8	442	10.2
18–55										
Hispanic	1,170	1,141	64.3†	2.58	59.8†	2.95	50*	4.3	71†	6.1
Non-Hispanic	2,189	2,167	66.1	1.87	58.7	1.82	41	1.9	150	6.8

* Males and females, whites and nonwhites, and subjects of Hispanic and non-Hispanic origin. Statistically significant different between categories, $p < 0.01$.

† Not statistically significant different between categories, $p > 0.05$.

The mean ΔFVC and ΔFEV_1 and the standard error of the mean (SEM) for males and females, subjects of Hispanic origin and non-Hispanic origin, and white and nonwhite subjects are listed in table 2. Overall a slightly higher percentage of female subjects failed to meet the ATS recommended acceptability criterion than males, and males showed a significantly larger mean difference (ΔFVC and ΔFEV_1).

The mean ΔFVC and ΔFEV_1 and SEM for 14 (males) and 13 (females) in different height groups are shown in figures 3 (males) and 4 (females). From these figures it appears that the mean ΔFVC and ΔFEV_1 are approximately uniform for all heights. In addition, a uniform or slightly decreasing mean ΔFVC and ΔFEV_1 were observed with respect to FVC and FEV_1 (not shown). These findings were unexpected since the ATS reproducibility criterion for volumes greater than 2 L is 5% of the FVC or FEV_1, indicating an expectation that these differences (measure of reproducibility) would increase with increasing lung size or its surrogate height. The dashed lines in figures 3 and 4 represent the ATS reproducibility limits for FEV_1 based on 5% of the mean FEV_1 for the respective height groups. The actual mean ΔFVC and ΔFEV_1 are lower than these limits and do not increase with increasing height. Therefore taller subjects are less likely to exceed these ATS reproducibility limits than shorter subjects.

The percentage of subjects who would fail to meet the ATS reproducibility criterion (applied to both FVC and FEV_1) as a function of their height group is shown in figure 5. Note that as height increases the number of subjects failing to meet the ATS reproducibility criterion decreases. This decreasing trend is observed even when the analysis is limited to subjects between the ages of 18 and 55 (dashed lines in figure 5). This decreasing trend is not explained by a lack of trials, as a higher percentage of both male and female shorter subjects had more than seven maneuvers. For example, 15%

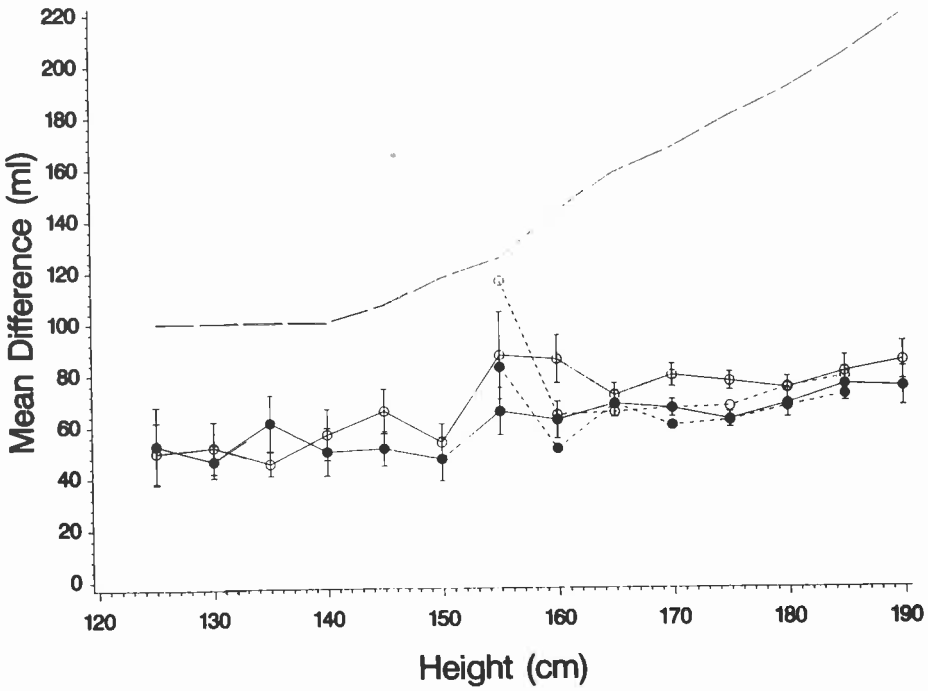

Fig. 3. For males the mean ΔFVC (ml; *open circles*) and mean ΔFEV_1 (*filled circles*) by height, ages 8 to 90 yr. Dashed lines indicate the results for the adult age group (ages 18 to 55). Long dashed line indicates the ATS reproducibility criterion limit of 5% of the FEV_1 or 100 ml, whichever is greater. The ATS reproducibility limit for FVC is not shown. High-low bars indicate ± 1 SEM.

(12 of 80) of the adult male subjects with a height of less than 162.5 cm had more than seven maneuvers, but only 6.4% (13 of 203) of male adult subjects with a height of greater than 182.5 cm had more than seven maneuvers.

When a constant-volume reproducibility criterion of 200 ml (based on the 95th confidence interval calculations of the ΔFVC and ΔFEV_1) is applied to FVC and FEV_1, there appears to be less of a relationship between the percentage of subjects with a nonreproducible test and height (figure 6). Shorter subjects fail to meet the 200-ml reproducibility criterion at about the same rate or less than the taller subjects.

A separate analysis was conducted using a linear model of the ΔFVC and ΔFEV_1 as a function of the continuous variables of age, height, percentage of predicted FVC, percentage of predicted $FEV_1/FVC\%$, and the indicator variables of sex, race, and Hispanic origin. Of all these parameters only the relationship between height and ΔFVC and ΔFEV_1 was not statistically significant. This linear model analysis was repeated leaving the percentage of predicted values (FVC and $FEV_1/FVC\%$) out of the equation and the same results were obtained.

When the linear model analysis was conducted using only the ΔFVC and ΔFEV_1 for the adults between the ages of 18 to 55, the relationship between height and ΔFVC and ΔFEV_1 was not statistically significant. In addition, the relationship between age and ΔFEV_1 was no longer statistically significant but was for the ΔFVC ($p < 0.05$). These linear model results appear to be consistent with the results shown in table 2 and figures 3 and 4.

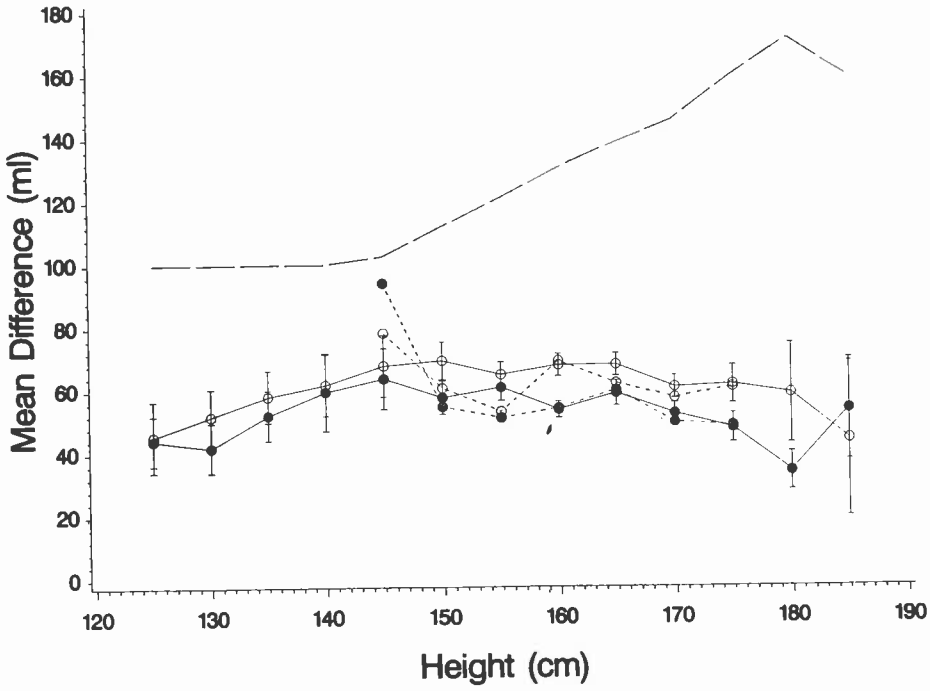

Fig. 4. For females the mean ΔFVC (ml, *open circles*) and mean ΔFEV_1 (*filled circles*) by height, ages 8 to 90 yr. Dashed lines indicate the results for the adult age group (ages 18 to 55). Long dashed line indicates the ATS reproducibility criterion limit of 5% of the FEV_1 or 100 ml, whichever is greater. The ATS reproducibility limit for FVC is not shown. High-low bars indicate ± 1 SEM.

Discussion

Although our analyses were based on preliminary data of 6,486 subjects, these results indicate that younger and especially older subjects have more difficulty meeting the ATS acceptability and reproducibility criteria. At least a portion of the failure to meet the ATS reproducibility criterion may be due to the smaller heights and lung volumes observed in these subjects, particularly the younger subjects. Factors other than ability to understand the test procedure may be related to test reproducibility. Specifically, there appears to be a difference in test variability between males and females and whites and nonwhites in the absence of a difference in the percentage of subjects with fewer than three acceptable curves (table 2). In contrast to these groups, subjects of Hispanic origin had a higher percentage of fewer than three acceptable curves, but test variability (ΔFVC and ΔFEV_1) was not significantly different.

A particularly important finding of this study is the relatively uniform within-

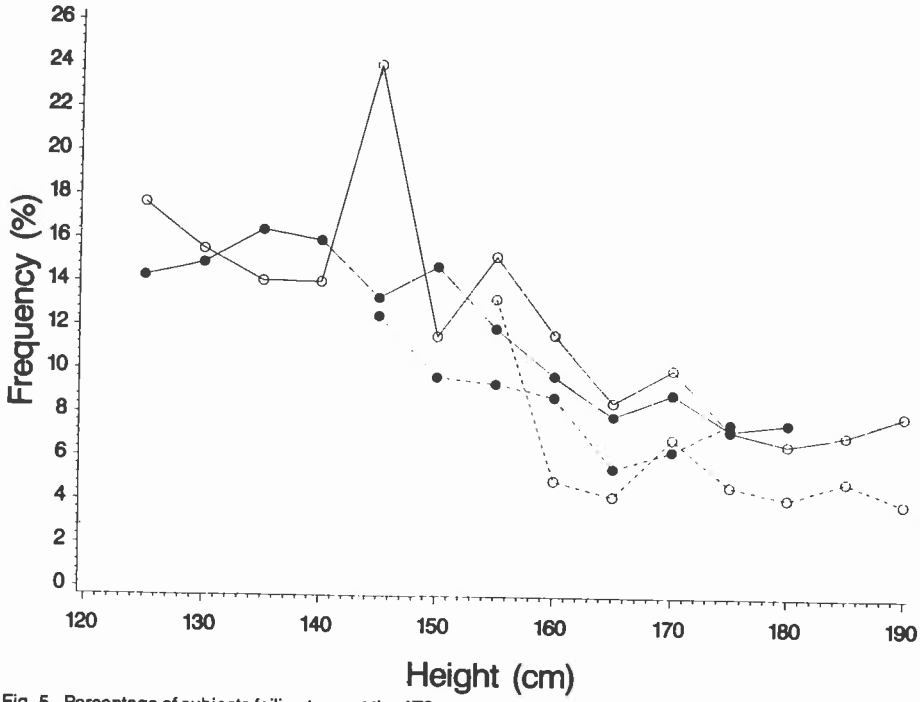

Fig. 5. Percentage of subjects failing to meet the ATS reproducibility (applied to FVC and FEV_1) criterion by height, ages 8 to 90 yr. Open circles indicate males, closed circles indicate females, and dashed lines represent the results for the adult age group (ages 18 to 55).

subject variability of FVC and FEV_1 in terms of the mean ΔFVC and ΔFEV_1 versus height (figures 3 and 4) and lung volumes. These results suggest that the ATS reproducibility criterion based on a percentage of the FVC and FEV_1 and a constant 100 ml for volumes less than 2 L may inappropriately classify a higher percentage of subjects with smaller heights and consequently smaller lung volumes as having a nonreproducible test. In contrast, taller subjects with larger lung volumes are much less likely to fail the ATS reproducibility requirement.

For comparison we tested a 200-ml reproducibility criterion (largest FVC and second largest FVC within 200 ml and largest FEV_1 and second largest FEV_1 within 200 ml). When this 200-ml reproducibility criterion is used the percentage of subjects failing to meet the reproducibility criterion does not appear to be related to height (figure 6), whereas this relationship was observed with the current ATS recommended reproducibility criterion (figure 5).

That the ATS reproducibility criterion was used in the collection of these data does not explain these results, as application of the ATS reproducibility criterion would tend to diminish the effects seen in figure 5. Since taller subjects with larger lung volumes are less likely to receive additional coaching because of their failure to meet the ATS criterion, one would expect the mean differences to be greater in these subjects, not less as was observed. Likewise, the shorter subject with smaller volumes received more coaching and therefore should have a smaller difference. We observed approximately the same mean ΔFVC and ΔFEV_1 for all heights or volumes, despite any coaching effect.

One possible explanation for the uniformity in the variability of FVC and FEV_1 is that subjects with smaller heights (primarily younger subjects) have more difficulty understanding and performing the test and therefore have a higher variability, even if they performed more maneuvers than the adults. To investigate this possibility an analysis of adults between the ages of 18 and 55 was conducted and produced results similar to those for the total population. Also, in the results using the linear model height was not significantly related to the ΔFVC or ΔFEV_1 for either the total population or the adult group.

Several studies have questioned the elimination of subjects for failure to meet a reproducibility criterion because such practice may introduce a population bias (4–6). Subjects with lung disease, particularly obstructive lung disease, have a greater test variability and may be preferentially eliminated. Our analysis using a linear model supported this observation, in that the FVC and FEV_1 variabilities were found to be related to the percentage of predicted FVC and the percentage of predicted FEV_1/FVC%. In addition, our results suggest that elimination of subjects for failure to meet a reproducibility criterion may also introduce a population bias with respect to subjects with smaller heights and lung volumes. Since subjects with moderate or severe obstructive lung disease tend to have lower FEV_1, it is possible that the preferential elimination of these subjects may be due in part to their lower FEV_1 combined with the ATS reproducibility criterion, rather than entirely to the larger within-subject variability of FVC and FEV_1 associated with disease. In our study a higher percentage of the subjects older than 55 fell below Knudson's lower limit of normal for FVC and FEV_1/FVC%, which could partially explain the relatively high rate of failure to meet the ATS reproducibility criterion in older subjects.

One natural consequence of a uniform ΔFVC and ΔFEV_1 expressed in milliliters is that the ΔFVC and ΔFEV_1, expressed as a percentage of FVC or FEV_1, would increase with decreasing FVC and FEV_1.

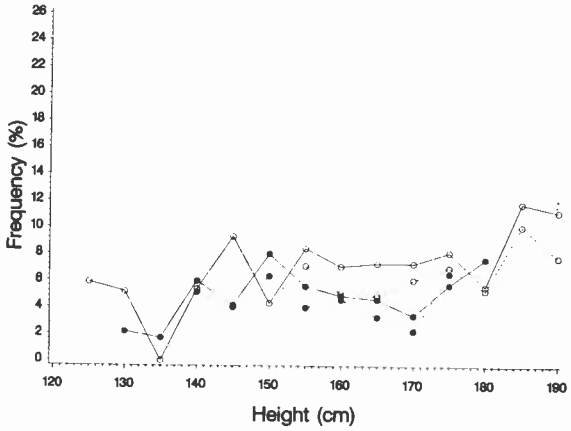

Fig. 6. Percentage of subjects failing to meet a 200-ml reproducibility criterion by height, ages 8 to 90 yr. Open circles males, closed circles females, and dashed lines represent the results for the adult age group (ages 18 to 55).

This means that subjects with smaller volumes (e.g., FVC and FEV_1) will have a much higher variability expressed as a percentage than subjects with larger volumes.

Although the ATS does not recommend excluding subjects for failure to meet their reproducibility criterion, it does recommend that reproducibility be considered in the interpretation of results. Therefore the impact of an inappropriate use of the reproducibility criterion may have consequences greater than simply having the subject perform additional unnecessary FVC maneuvers. A 200-ml reproducibility criterion may provide a commensurable level of difficulty for all subjects, regardless of age or lung volume. The practice of classifying a patient as having an invalid test based on failure to meet the ATS reproducibility criterion may nevertheless place shorter subjects with smaller lung volumes at a disadvantage.

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Public Health

Project SENSOR: Wisconsin surveillance of occupational carpal tunnel syndrome

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OUR MODERN SOCIETY is founded on increasingly complex industrial processes. While virtually all industries are experiencing greater automation, manual labor has not been eliminated. For many workers, an eight hour work shift means highly stereotypic, manual tasks repeated hundreds if not thousands of times while working with machines, hand tools, and on assembly lines. When these biomechanical stresses accumulate beyond a worker's adaptive limits, a repetitive trauma disease may result. One such disorder is carpal tunnel syndrome.

Background

Carpal tunnel syndrome (CTS) is a compression neuropathy of the median nerve at the wrist.[1] It is a fairly common disorder having many etiologies.[1-4] CTS is characterized by symptoms arising in the distribution of the median nerve to the hand, including "paresthesias, pain and numbness in the palmar side of the thumb, index finger, middle finger, and radial half of ring finger; and the dorsal side of the same digits distal to the proximal interphalangeal joint, and radial half of the palm."[2] Additionally, weakness and atrophy of the thenar muscle can occur.[1-3] Sensory manifestations often precede muscle weakness and symptoms are frequently more severe at night.[1,3]

Non-occupational factors jeopardizing the median nerve through compression or ischemia include diabetes, pregnancy, rheumatoid arthritis, and gout.[3,5] Work-related carpal tunnel syndrome is caused by cumulative biomechanical stresses on the hands and wrist.[2,3,5] Silverstein[5] identified six occupational causes:

- repetitive movements of the wrists or fingers with loading of the tendons in the carpal tunnel;
- forceful contraction of these tendons;
- extreme flexion or extension of the wrist, pinching or other awkward postures;
- mechanical stresses over the course of the median nerve of the hand;
- exposure to vibration; and
- the use of poorly fitting gloves, and exposure to cold. Occupations with combinations of factors are at greater risk than jobs with only one risk factor.[5]

Occupational disease surveillance is hampered because of inadequate information systems, multiple etiologies, and unrecognized occupational disease: clinicians fail to record a work history, and then cannot possibly link the disease to the workplace.[6] Under the Sentinel Event Notification System for Occupational Risks (SENSOR) program,[2,7] Wisconsin is developing a pilot CTS surveillance program by obtaining physician case reports, and Workers Compensation (WC) CTS cases. Since January 1989,

Continued on page 82

From the Research and Surveillance Unit, Section of Environmental and Chronic Disease Epidemiology, Wisconsin Division of Health. Hanrahan is the supervisor of the unit; Higgins is the SENSOR Project Coordinator; Dr Anderson is chief of the section; Haskins is the public health educator; Dr Tai is the director for the Bureau of Compensation Performance, Workers Compensation Division, Department of Industry, Labor, and Human Relations. This project was made possible through grants from the National Institute for Occupational Safety and Health, and in cooperation with the Agency for Toxic Substances and Disease Registry, US Public Health Service. Copyright 1991 by the State Medical Society of Wisconsin.

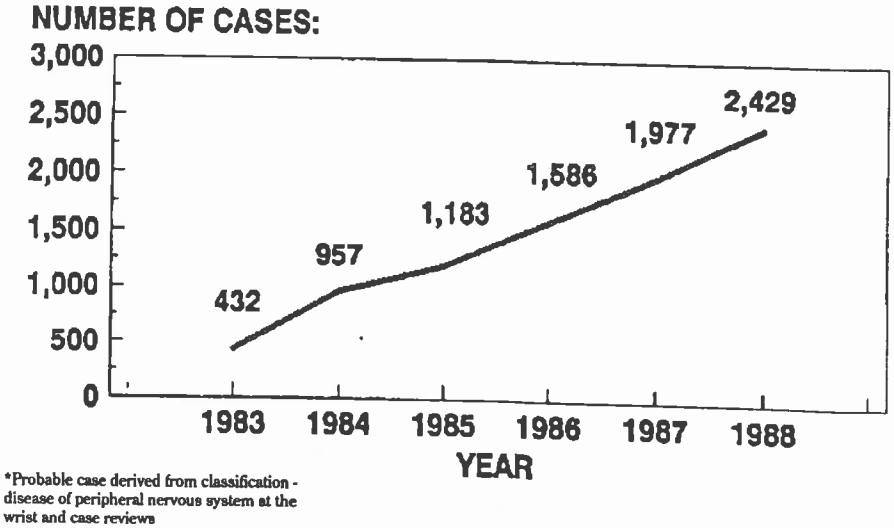

Fig 1.–Wisconsin Workers Compensation carpal tunnel syndrome cases, 1983-1988 (n=8595).*

Continued from page 80
17 physicians have reported occupational CTS using the SENSOR case definition.[2,7] Since January 1988, the computerized WC file has been routinely accessed to search for CTS cases.

Workers compensation surveillance

Since 1983, Wisconsin has seen more than a five-fold increase in the reporting of WC-CTS cases. WC-CTS cases have risen from 432 per year in 1983 to 2,429 in 1988, representing an increase from approximately 2.5 cases to 11.5 cases per 10,000 workers annually (Fig 1).

Meat packing and poultry processing industries demonstrated the greatest elevated WC-CTS risk (Fig 2). These risks are over 10 times the all industry average of seven cases per 10,000 workers for the entire time period. Other risk elevated industries included the manufacture of motor vehicle car bodies, and internal combustion engine manufacturing.

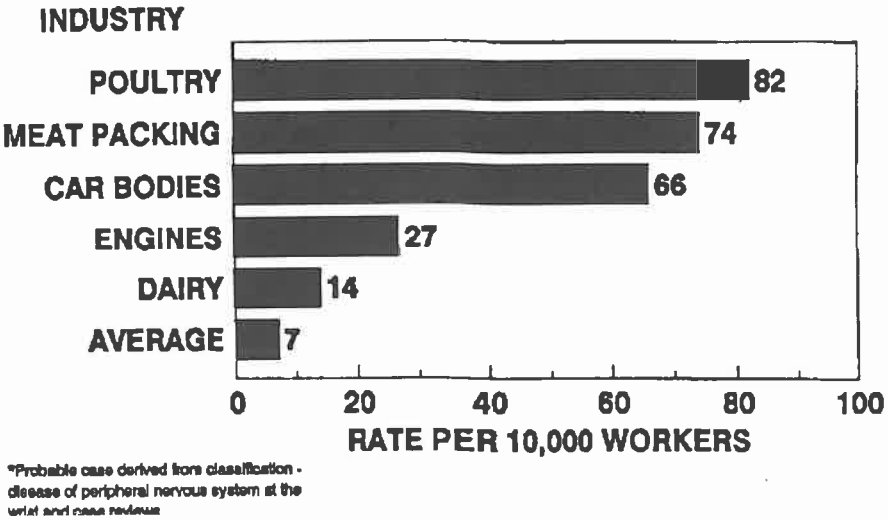

Fig 2.–Wisconsin Workers Compensation carpal tunnel syndrome cases by industry, 1983-1988.*

Occupations in which highly repetitive, manual tasks predominate were at highest risk (Table 1). Dental hygienists and data entry keyers were at greatest risk. Electronic equipment assemblers, hand cutting occupations, sewing machine operators, assemblers and butchers all experienced an increased risk for WC-CTS.

A total of 82% of the WC-CTS cases were settled as of March, 1990. These cost more than $33 million for compensation and medical benefits. These averaged $4,700 each, with $1,400 for medical treatment costs. Average medical costs are most likely underestimated because, in many cases, all of the medical changes are not reported to the WC system.

Table 1.–Wisconsin Workers Compensation carpal tunnel syndrome* case-referent analysis of high risk occupations, 1983-1988 (n=8,595).

Occupation	No. of cases	Odds** ratio
dental hygienists	26	15.5
data entry operators	60	12.2
electronic equipment assembler	22	9.6
hand cutting occupations	148	7.4
hand grinding	52	5.8
sewing machine operator	128	5.6
misc. hand working occupations	212	4.8
assemblers	1310	4.2
hand packagers	337	3.3
metal and plastic processors	63	2.9
butchers and meat cutters	212	2.8
package machine operators	101	2.1
grinding machine operators	146	1.9
misc. machine operators	358	1.7
slicing machine operator	125	1.7

*Probable case derived from classification-disease of peripheral nervous system at the wrist and case reviews.
**Ratio of odds of occupation in case series v odds of occupation in referent series (all other workers compensation cases). Odds ratio greater than 1 increases CTS risk.

SENSOR CTS surveillance

Since January 1989, 300 occupational CTS cases have been reported by physicians to the SENSOR program. In 54% of the cases, diagnosis indicated bilateral involvement; 35% were limited to the right upper extremity. Many high risk WC-CTS industries were also found in the SENSOR-CTS series (Table 2). Job characteristics were noted, and 72% of the cases were found to have highly stereotypic, repetitive movements. Twenty-one percent were characterized by forceful use of the hands, 14% had awkward postures, and 13% required a pinch grip.

Comment

There has been a dramatic increase in occupational CTS in Wisconsin as

reported through Workers Compensation. These and the SENSOR CTS cases predominate in industries and occupations requiring highly repetitive and forceful manual tasks. CTS cases have been very costly for both employers and employees.

There are many possible reasons for the increased case load. These include better recognition, reporting, and treatment; the aging of the work force into higher risk age groups; increased productivity demands, and changing job tasks as industrial processes evolve.

Occupational CTS is preventable. Because it is caused by workplace biomechanical hazards, their reduction and elimination can reduce CTS incidence.[4,5] Ergonomic control measures are the foundation for CTS hazard elimination.[3-5]

Because surveillance involves the analysis and dissemination of health information to those who need to know, the Wisconsin Division of Health conducted three seminars on CTS prevention strategies in 1990. Two more are planned for 1991. The seminars have reached over 500 individuals, including health care providers, and over 131 employers from high CTS risk industries.

Increasingly, physicians will be asked to provide comprehensive medical management of cases as CTS concern grows. When CTS is caused by a workplace, it is important to remember that unless underlying work conditions are addressed, any medical treatment, including surgery, cannot be expected to provide permanent relief.

Table 2. – Wisconsin SENSOR occupationally induced carpal tunnel syndrome case frequency by industry, January 1989-September 1990 (n=188 industry coded cases).

SIC* code	Industry	No. of cases	%
35	machinery mfg	31	16
30	rubber and plastics	25	13
80	health services	11	6
33	primary metal mfg	11	6
20	food products	9	5
36	electronic equipment mfg	8	4
23	apparel mfg	7	4
17	specialty construction	6	3
26	paper products mfg	5	3
22	textile mills	4	2
37	motor vehicle equipment mfg	4	2
54	grocery, food stores	4	2
24	lumber and wood products	4	2

*Standard industrial classification, 2-digit.

Series coordinators

The Wisconsin Division of Health's Henry Anderson, MD, chief of the Section of Environmental and Chronic Disease Epidemiology, and Patrick Remington, MD, are coordinating this series for the *Wisconsin Medical Journal*. Physicians desiring to learn more about occupational carpal tunnel syndrome and its prevention are encouraged to attend the seminars sponsored by the Wisconsin Division of Health. Continuing medical education credits will be granted. For more information, contact Dee Higgins, RN (608-267-3256).

Acknowledgements

The authors appreciate the assistance of Patrick Remington, MD, in reviewing drafts of this manuscript.

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Texas Department of Health

Robert Bernstein, M.D., F.A.C.P.
Commissioner

1100 West 49th Street
Austin, Texas 78756-3199
(512) 458-7111

Robert A. MacLean, M.D.
Deputy Commissioner

March 15, 1991

DEAR DOCTOR:

The Epidemiology Division, Texas Department of Health, is responsible for coordinating occupational disease surveillance in Texas as mandated by the Texas Occupational Disease Reporting Act. Surveillance refers to the ongoing examination of the occurrence and distribution of disease. Knowledge of disease occurrence can be used to apply control measures effectively. We have enclosed a pamphlet entitled "Reportable Occupational Diseases in Texas" for your information.

We are conducting a survey to obtain information about pesticide poisoning. We have listed below some questions for your reply. Please insert your answers and return this letter to our office by **April 30, 1991.** An addressed stamped envelope is provided for your convenience. Your assistance is greatly appreciated as your information will contribute significantly to the knowledge about occupational diseases in Texas. If you have any questions, you may contact Laurel Schulze or Teresa Willis at 512/458-7269.

Sincerely,

Diane M. Simpson, Ph.D., M.D.
Associate Commissioner
Disease Prevention

DID YOU TREAT ANY PATIENTS FOR PESTICIDE POISONING IN 1989 & 1990?
Check one: YES ☐ NO ☐

IF YES, HOW MANY OF THESE HAD OCCUPATIONAL EXPOSURES?
Check one: 0 ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ >15 ☐

CIRCUMSTANCES OF EXPOSURE: CHECK ALL THAT APPLY
Agricultural Application: aerial ☐ ground ☐ mining/loading ☐
Commercial/residential application ☐ Pesticide manufacture/formulation ☐
Work in recently treated field ☐ Other worksite ☐ Other ☐

Appendix D

Pesticide Poisoning Letter and Questionnaire

Appendix A

Hospitals by Counties and Cities and Number of Hospital Beds by Facility

Hospitals by Counties and Cities
and Number of Hospital Beds by Facility

County	Hospital	City	Licensed Beds
Crosby	Crosbyton Clinic Hospital	Crosbyton	50
Garza	Garza Memorial Hospital	Post	26
Floyd	Lockney General Hospital	Lockney	20
	Caprock Hospital District	Floydada	40
Hale	Hi-Plains Hospital	Hale Center	40
	Central Plains Regional Hospital	Plainview	151
Hockley	Methodist Hospital	Levelland	78
Lamb	Lamb Healthcare Center	Littlefield	75
Lubbock	Highland Medical Center	Lubbock	123
	Methodist Hospital		715
	St. Mary's of the Plains Hospital		429
	South Park Medical Center		99
	University Medical Center		301
	West Texas Hospital		166
Lynn	Lynn County Hospital District	Tahoka	24
Terry	Brownfield Regional Medical Center	Brownfield	97
9 counties	**16 hospitals**	**11 cities**	**2434 beds**

APPENDIX B

International Classification of Disease (ICD) Codes Including External Cause (E) Codes

International Classification of Disease (ICD)
Codes Including External Cause (E)
Codes

ICD Code	Description
349.9	Unspecified disorders of nervous system
506	Respiratory conditions due to chemical fumes and vapors
692	Contact dermatitis and eczema
981	Toxic effect of petroleum products
982	Toxic effect of solvents other than petroleum-based
983	Toxic effect of corrosive aromatics, acids, and caustic alkalis
984	Toxic effect of lead and its compounds (including fumes)
985	Toxic effect of other metals
987	Toxic effect of other gases, fumes, or vapors
989	Toxic effect of other substances, chiefly nonmedicinal as to source
E862	Accidental poisoning by petroleum products, other solvents and their vapors, not elsewhere classified
E863	Accidental poisoning by agricultural and horticultural chemical and pharmaceutical preparations other than plant foods and fertilizers
E864	Accidental poisoning by corrosives and caustics, not elsewhere classified
E866	Accidental poisoning by other and unspecified solid and liquid substances
E980	Poisoning by solid or liquid substances, undetermined whether accidentally or purposely inflicted
E980.7	Agricultural and horticultural chemical and pharmaceutical preparations other than plant foods and fertilizers
E980.8	Arsenic and its compounds
E980.9	Other and unspecified solid and liquid substances

Appendix C

Acute Occupational Pesticide Poisoning Surveillance Case Report

TDH Case # _____
Date Report Received at TDH ____/____/____
MM DD YY
Source of Initial Report _____
(TDH Use Only)

ACUTE OCCUPATIONAL PESTICIDE POISONING SURVEILLANCE CASE REPORT
TEXAS DEPARTMENT OF HEALTH, BUREAU OF EPIDEMIOLOGY

DEMOGRAPHIC INFORMATION

LAST NAME | FIRST NAME | MIDDLE INITIAL

STREET ADDRESS | CITY | ZIP CODE | COUNTY | COUNTY CODE (TDH use only)

TELEPHONE NUMBER ( ) | DATE OF BIRTH ____/____/____ MM DD YY | AGE | SEX ____ 1 MALE ____ 2 FEMALE | SOCIAL SECURITY NUMBER _____-_____-_____

RACE/ETHNICITY
____ 1 WHITE, NOT HISPANIC ____ 2 HISPANIC ____ 3 BLACK
____ 4 AMERICAN INDIAN/ALASKAN NATIVE ____ 5 ASIAN/PACIFIC ISLANDER

ENGLISH SPEAKING
____ 1 YES
____ 2 NO

NAME OF EMPLOYER (COMPANY OR BUSINESS) AT TIME OF PESTICIDE EXPOSURE

STREET ADDRESS | CITY | ZIP CODE | COUNTY | COUNTY CODE (TDH use only)

TYPE OF BUSINESS | INDUSTRY CODE (TDH use only)

JOB (TYPE) AT TIME OF EXPOSURE TO PESTICIDE | OCCUPATION CODE (TDH use only)

ARE THERE NONOCCUPATIONAL ACTIVITIES THAT MAY HAVE RESULTED IN PESTICIDE EXPOSURE? ____ 1 YES ____ 2 NO
IF YES, PLEASE DESCRIBE:

EXPOSURE INFORMATION

LOCATION OF PESTICIDE EXPOSURE (If rural, directions from the nearest town)
STREET ADDRESS | CITY | ZIPCODE | COUNTY | COUNTY CODE (TDH use only)

DATE OF EXPOSURE ____/____/____ MM DD YY

TIME OF EXPOSURE
____ a.m.
____ p.m.

CIRCUMSTANCE OF EXPOSURE
____ 1 Agricultural Application
____ aerial ____ ground
____ mining/loading
____ 2 Commercial/Residential Application
____ 3 Work in Recently Treated Field/Other Work Site
____ 4 Pesticide Manufacturer/ Formulation
____ 5 Other _____

TYPE OF PESTICIDE (Check all that apply)
____ 1 Insecticide
____ 2 Herbicide
____ 3 Fungicide
____ 4 Rodenticide
____ 5 Disinfectant
____ 6 Other (specify) _____
____ 7 Unknown

Formulation Type
____ 1 aerosol/spray
____ 2 dust/granular
____ 3 bait
____ 4 liquid

Route of Exposure
____ 1 Dermal
____ 2 Ingestion
____ 3 Inhalation
____ 4 Other _____
____ 5 Unknown

PRODUCT NAME(S)	EPA REGISTRATION NO (from label)	ACTIVE INGREDIENTS (from label)	INGREDIENT CODES (TDH use only)

REPORTING (OR ATTENDING) PHYSICIAN | ADDRESS | TELEPHONE

( )

DIAGNOSIS BASED UPON (Check all that apply):

____ 1 Known Exposure
____ 2 Symptomatology
____ 3 Diagnostic laboratory tests
____ 4 Pesticide Residue/Metabolites
____ 5 Other _____

SIGNS/SYMPTOMS/SEQUELAE (Check all that apply):

Nervous/Sensory
____ 1 Yes
____ 2 No

____ 101 Ataxia
____ 103 Blurred/dark vision
____ 105 Coma
____ 107 Confusion
____ 109 Convulsions
____ 111 Dissiness
____ 113 Eye Irritation
____ 115 Fainting/Unconscious
____ 117 Headache
____ 119 Hyperactivity
____ 121 Numbness (location) _____
____ 123 Paralysis
____ 125 Pinpoint pupils
____ 127 Sweating profusely
____ 129 Tremors
____ 131 Weakness
____ 133 Other _____

Cardiovascular
____ 1 Yes
____ 2 No

____ 201 Cyanosis
____ 203 Rapid/Slow heartbeat
Specify _____
____ 205 Hypertension/Hypotension
Specify _____
____ 207 Other _____

Gastrointestinal/Liver
____ 1 Yes
____ 2 No

____ 301 Abdominal Pain/Cramps
____ 303 Diarrhea
____ 305 Jaundice
____ 307 Nausea/Vomiting
____ 309 Salivation
____ 311 Hepatomegally/Enlarged/ Tender Liver
____ 313 Other _____

Respiratory
____ 1 Yes
____ 2 No

____ 401 Chest tightness
____ 403 Difficulty breathing
____ 405 Pulmonary edema
____ 407 Shortness of Breath
____ 409 Nose/Throat irritation
____ 411 Wheezing
____ 413 Chest pain
____ 415 Coughing
____ 417 Other _____

Renal/Urinary
____ 1 Yes
____ 2 No

____ 501 Incontinence
____ 503 Renal failure
____ 505 Hematuria/proteinuria
____ 507 Other _____

Other
____ 1 Yes
____ 2 No

____ 601 Fatigue
____ 603 Malaise
____ 605 Skin irritation/rash
____ 607 Hematopoietic
____ 609 Musculoskeletal
____ 611 Hyperthermia/Fever
____ 613 Other _____

Date of Death, if deceased

____/____/____
MM DD YY

Type of Medical Care:

____ 1 Physician office visit
____ 2 Emergency room visit
____ 3 Hospital admission _____
No of days

Residual Signs or Symptoms:

_____

_____

at (number days post exposure)

_____

LABORATORY TESTS DONE ____ 1 Yes ____ 2 No (If yes, complete below. Attach laboratory reports, if available.)

NAME OF LABORATORY(IES) | ADDRESS | TELEPHONE

( )

PESTICIDE RESIDUE/METABOLITES IN BODY FLUIDS/TISSUE, ETC?

____ 1 yes (complete below) ____ 2 No ____ 3 Not obtained

1 ____ Unknown substances only found
2 ____ Low levels found, consistent with suspected pesticide(s)
3 ____ Significant levels found, consistent with suspected pesticide(s)

DATE OF SAMPLE

____/____/____
MM DD YY

CHOLINESTERASE LEVELS OBTAINED
(Document laboratory methods, dates, and levels obtained.)

____ 1 Yes ____ 2 No

If yes: ____ 1 All normal ____ 2 Abnormal (complete below)
____ 1 only rbc cholinesterase low
____ 2 only plasma cholinesterase low
____ 3 both plasma and rbc cholinesterase low

Date	Laboratory Method	Rbc/ Plasma	Result
___/___/___	_____	_____	_____
___/___/___	_____	_____	_____
___/___/___	_____	_____	_____
___/___/___	_____	_____	_____

____ 1 Elevated SGOT
____ 2 Elevated BUN
____ 3 Elevated SGPT
____ 4 Elevated LDH
____ 5 Elevated creatinine
____ 6 Elevated Alkaline
____ 7 Other _____

OTHER RELEVANT (NORMAL OR ABNORMAL) LABORATORY/HISTOLOGIC/AUTOPSY FINDINGS

_____

_____

_____

FORM COMPLETED BY

NAME: _____

TITLE: _____

AGENCY: _____

DATE: ___/___/___
MM DD YY

TDH USE ONLY

____ CASE CONTACTED
____ INDUSTRIAL ASSESSMENT CONDUCTED
____ EMPLOYER CONTACTED
____ REFERRED TO ANOTHER AGENCY _____
(specify where)
____ OTHER CASES DISCOVERED
____ ENTERED INTO TDH BUREAU OF EPIDEMIOLOGY REGISTER

RETURN COMPLETED FORM TO:

ATTENTION: TERESA M. WILLIS
EPIDEMIOLOGY DIVISION
TEXAS DEPARTMENT OF HEALTH
1100 WEST 49TH STREET
AUSTIN, TEXAS 78756

REPORTING OF OCCUPATIONAL PESTICIDE POISONINGS *

TEXAS SOUTHERN HIGH PLAINS REGION

1989 - 1990

September 25, 1991

Judith P. Henry, M.S.
Teresa Willis
Laurel Schulze
Suzanne Hahn, D.V.M.

Environmental Epidemiology Program
Epidemiology Division
Texas Department of Health

* This project was funded through the National Institute of Occupational Safety and Health's TxSENSOR cooperative agreement with the Texas Department of Health.

INTRODUCTION

Acute occupational pesticide poisoning became a reportable disease in Texas in 1985 with the passage of the Texas Occupational Disease Reporting Act. The Act requires that all confirmed or suspected cases of acute occupational pesticide poisoning be reported to the Texas Department of Health (TDH). Reporting is the responsibility of physicians, laboratory directors, and/or any person in charge of a clinic or hospital laboratory, blood bank, mobile unit or other facility in which a laboratory examination records evidence of the reportable disease. The award of a National Institute of Occupational Safety and Health (NIOSH) cooperative agreement to the TDH Environmental Epidemiology Program in 1987 allowed the TDH to expand its surveillance of occupational pesticide poisoning.

Agriculture is one of the most important industries in Texas. Texas ranked second among all 50 states in cash receipts for farm and ranching marketings in 1988 and 1989 (1). The 1990 Texas agriculture labor force, including farm and ranch workers, was estimated to be 227,000. This included 142,000 self-employed workers, 30,000 unpaid workers (including family members), and 55,000 hired workers (2).

TDH has made a concerted effort over the last several years to increase awareness of occupational pesticide poisoning and the occupational disease reporting requirements. Given the nature and size of the agricultural industry, the number of reported cases of pesticide poisonings has remained disproportionately small. Less than 25 cases of occupational pesticide poisoning were reported annually to the TDH from 1985 to 1989. In 1990, 60 cases were reported. This dramatic increase, however, was due to a single incident in which 44 office workers were affected by the misapplication of a pesticide in their office building.

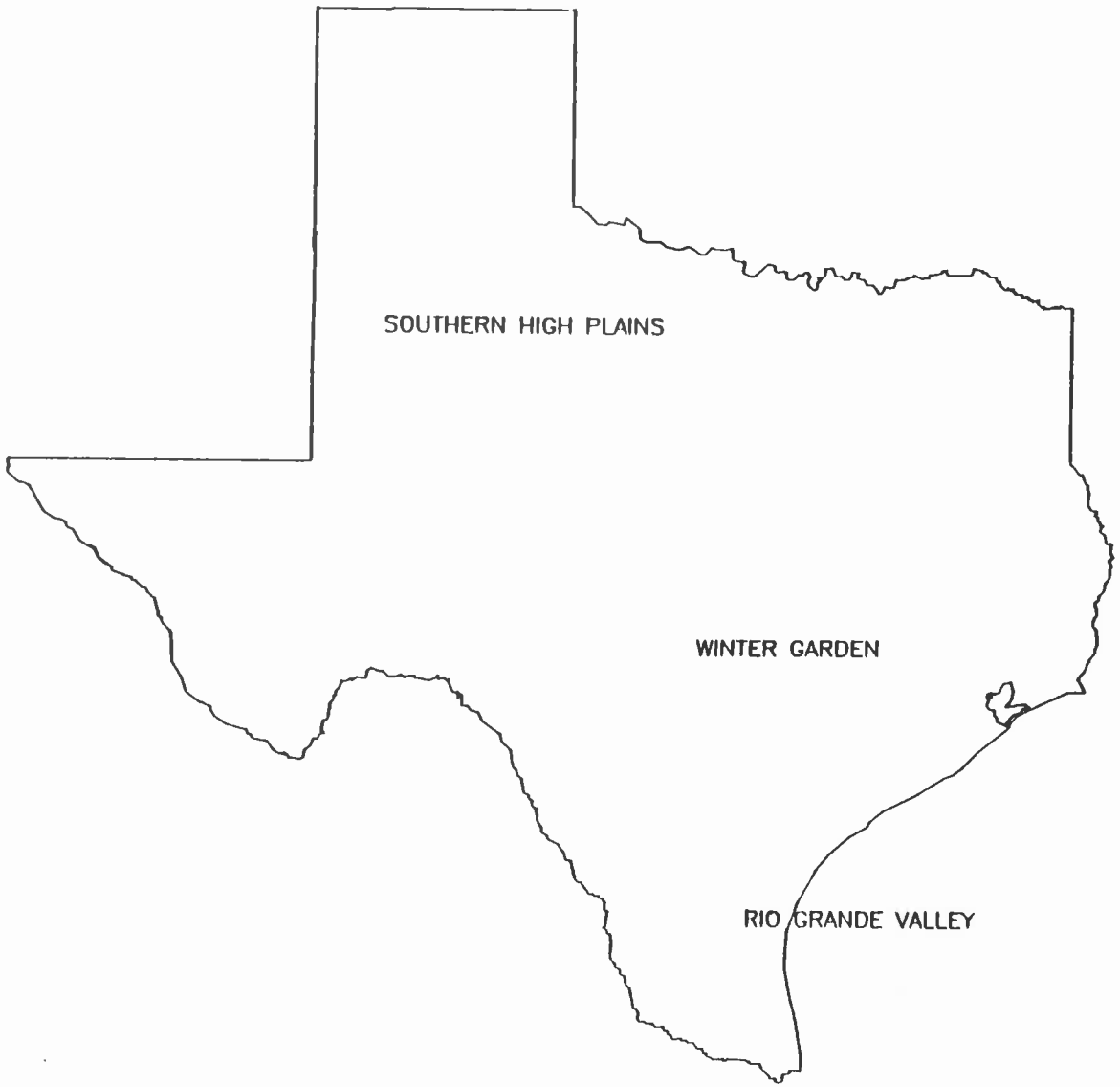
To investigate potential causes for the apparent underreporting of occupational pesticide poisonings, the TDH initiated a study in one of the state's major agricultural growing regions - the Southern High Plains. The primary objective of this study was to identify all cases of occupational pesticide poisoning in the area for 1989 - 1990 in order to determine to what extent cases were underreported and to attempt to identify barriers to reporting. A secondary goal of the study was to increase awareness of the problem of occupational pesticide poisonings and to increase the awareness of the reporting requirements of the Texas Occupational Disease Reporting Act. The study was funded through the NIOSH TxSENSOR cooperative agreement.

BACKGROUND

The Southern High Plains, located in the Panhandle in northern Texas, is one of three major geographic regions in Texas in which labor-intensive crops are grown. The other two areas are the Winter Garden area, located in south central Texas, and the Rio Grande Valley, located in far south Texas (Figure 1). The Southern High Plains area was selected for study primarily because of its large distance from the Mexico-Texas border. The assumption was that

FIGURE 1

MAJOR AGRICULTURAL GROWING REGIONS



farmworkers would be less likely to seek nontraditional forms of health care in Mexico or in border communities and would be more likely to rely on the United States health care system for treatment in the case of pesticide poisoning.

Nine counties within the Southern High Plains region were selected for the study area. These nine counties include Lubbock, Crosby, Floyd, Garza, Hale, Hockley, Lamb, Lynn, and Terry (Figure 2). The region is a leading producer of grain, sorghum, and cotton. Lubbock County is the state's largest cotton producer. The terrain is flat and is conducive to mechanization with most of the crops in the area irrigated. The estimated agricultural workforce in the nine-county area for July 1990 was 6820 (2). This included the following categories: self-employed workers, unpaid family workers, workers hired for 150 days or more, and workers hired for 149 days or less. The figure also includes cattle workers.

Combined, the nine counties in the study area encompass 8,385 square miles - an area larger than the State of Massachusetts. The 1990 United States Census total for the nine counties is 337,498 (3). Approximately 64% of the population are non-Hispanic whites and 28% are Hispanic. The City of Lubbock is the largest metropolitan area in the Southern High Plains region and had a 1990 Census total of 186,206 (3). The City of Lubbock is located in Lubbock County.

There are a total of 17 hospitals and 7 migrant health clinics in the nine-county area, including one psychiatric hospital in the City of Lubbock. Six of the acute care hospitals, ranging in size from 99 to 715 licensed beds, are located in the City of Lubbock with the remaining 10 hospitals scattered in the rest of the counties. The largest hospital located outside of Lubbock is the Central Plains Regional Hospital in the City of Plainview in Hale County with 151 beds. The remaining hospitals outside of the Lubbock area ranged in size from 20 to 97 beds. Appendix A lists the hospitals by county and city and lists the number of licensed beds for each facility.

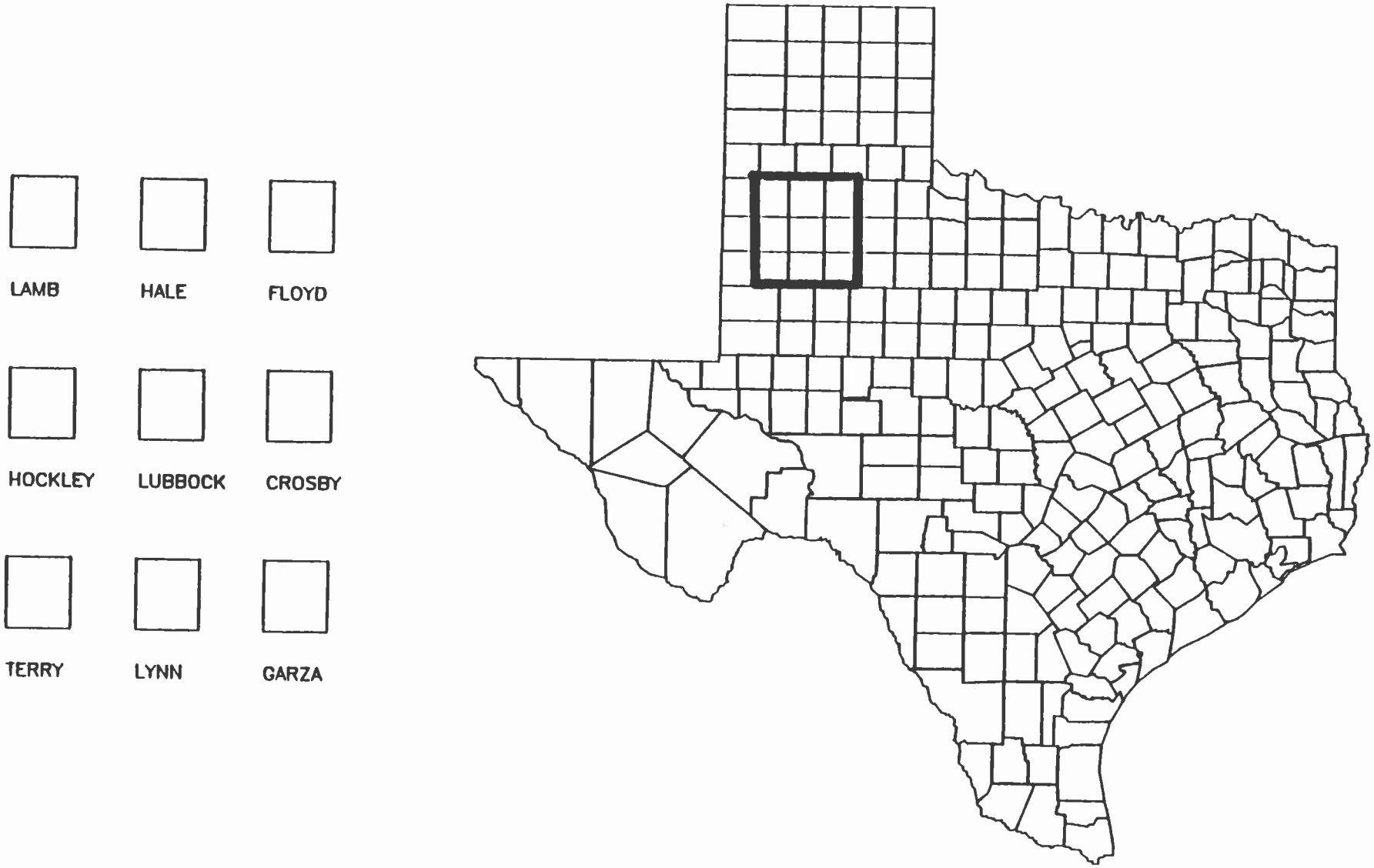
Prior to the initiation of the study, the TDH had contact with a total of 13 sentinel providers in the nine-county area. This included six private physicians and seven migrant health clinics. The sentinel providers are contacted by TDH staff on a regular basis to determine if they have seen any confirmed or suspected cases of occupational pesticide poisonings. The sentinel providers are also encouraged to report any cases of pesticide poisonings they might see on their own.

METHODS

The primary objective of the study was to identify all cases of occupational pesticide poisoning, confirmed or suspected, in the nine-county Southern High Plains growing area for 1989 and 1990 and to identify barriers to reporting. The study targeted the traditional health care delivery system including the 16 hospitals, migrant clinics, and private physicians. Case ascertainment for 1989 and 1990 was to be accomplished in a three phase process using the existing TDH surveillance data, hospital records, and a mail survey.

FIGURE 2

NINE-COUNTY STUDY AREA SOUTHERN HIGH PLAINS



A. Surveillance Data

Information collected by the TDH active surveillance system for occupational pesticide poisoning was reviewed to identify cases previously reported for 1989 and 1990. TDH maintains regular contact with the 13 sentinel providers in the nine-county area.

B. Hospital Records

A review of emergency room log books and medical records was performed by four TDH staff at the 16 acute care hospitals located in the nine-county area to identify any additional cases of occupational pesticide poisoning. Each hospital administrator and medical records director was contacted by letter two months before an on-site visit was scheduled to inform them of the purpose of the study and to provide information concerning the legislative authority to conduct such a study. Two weeks prior to the site visit to the hospital, a second letter which listed the expected date of arrival of the TDH team to review medical records was mailed to the hospitals. The letter requested the medical records directors to have available for review all 1989 and 1990 medical records with diagnoses of specified International Classification of Disease (ICD) codes (including external cause codes) related to pesticide poisoning (Appendix B) and the emergency room logs for 1989 and 1990. Each hospital was also contacted by phone prior to the arrival of the TDH team.

Once on-site at the hospitals, all medical records for 1989 and 1990 with the specified ICD Codes were reviewed to determine if the patient had been exposed to pesticides in an occupational setting. Once it was determined that the record did reflect a confirmed or suspected case of occupational pesticide poisoning, an "Acute Occupational Pesticide Poisoning Surveillance Case Report" form (see Appendix C) was completed using the information in the record.

Emergency room log books for each hospital were also reviewed in an attempt to identify potential cases treated in the emergency room, but not necessarily admitted to the hospital. A manual review of emergency room log books was necessary because the emergency room patient records were not coded and/or computerized. For two of the largest hospitals, the Methodist Hospital in Lubbock and University Medical Center, the emergency room logs for 1990 only were reviewed due to the large number of entries (approximately 30,000 entries per hospital) and time constraints. For the remaining 14 hospitals, emergency room log books for 1989 and 1990 were reviewed. The emergency room outpatient record was requested for review if the emergency room log entry indicated the injury or illness could be related to pesticide exposure. Once the determination was made, using the emergency room medical record, that the patient appeared to have been exposed to a pesticide in an occupational setting, an "Acute Occupational Pesticide Poisoning Surveillance Case Report" was also completed using the information contained in the record.

Due to the vast differences in the content and quality of information recorded in emergency room log books, additional objective and subjective criteria were used to determine which patients' emergency room records would be requested. In addition to the log entries mentioning any possibility of pesticide exposure, log entries which listed any type of chemical exposure and/or job-

related injury such as a burn or skin or eye irritation were identified and the outpatient records requested. Subjectively, medical records of emergency room log entries which listed Hispanic patients with unusual conditions or circumstances which could mimic pesticide exposure (ie. anxiety attacks and/or flu-like symptoms in non-flu seasons) were also reviewed.

C. Physician Survey

As an adjunct to the hospital records review to identify cases of pesticide poisoning, a mail survey of physicians in the nine-county study area was also conducted. The purpose of the mail survey was to obtain an estimate of the number of cases of occupational pesticide poisonings seen by physicians in their offices and, if possible, to obtain additional information about those cases. A one-page letter and questionnaire (Appendix D) was mailed to 674 physicians in the study area. Questionnaires were sent to every physician who had direct patient contact, irregardless of specialty.

The questionnaire consisted of three questions. The first question asked if the physician had treated any patients for pesticide poisoning in 1989 and 1990. The second question asked the physician to estimate the number of pesticide poisoning cases which had occupational exposure. The ranges given in the questionnaire were 0, 1-5, 6-10, 11-15, and greater than 15 cases of occupationally exposed pesticide poisoning. The third question concerned the circumstances of the occupational exposure. Physicians who indicated they had seen any cases of occupational pesticide poisoning were contacted a second time by letter and requested to either complete a case report form or to contact the TDH office. The physicians were also asked to become part of the TDH sentinel provider network to routinely report cases of pesticide poisoning.

RESULTS

A total of 12 cases of confirmed and/or suspected cases of pesticide poisoning were identified through a review of the TDH surveillance data and hospital record review. Table 1 lists a summary of case information. The results of the physician's survey indicated at least 12 cases of pesticide poisoning were seen in private offices. No additional case information was available, however, from the private physicians.

A. Surveillance Data

Two cases of occupational pesticide poisoning for the nine-county study area were identified for 1989 through the TDH active surveillance system data files. No cases were identified for 1990. Both cases for 1989 were white males age 17 and involved agricultural exposure. Case #1 involved exposure to an unidentified organophosphate insecticide. He presented for treatment in Lamb County. Case #2 was apparently exposed to several insecticides while flagging for the family's aerial applicator business. He was originally exposed in Gaines County (located immediately south of Terry County) and was

Table 1

Summary of Case Information

Case Number	Year	Sex	Age	Race*	Type of Pesticide	Location of Treatment Facility	Circumstances of Exposure
1	1989	M	17	W	insecticide	Lamb	agriculturel application
2	1989	M	17	W	insecticide	Gaines/Lubbock	agricultural application - aerial
3	1989	M	29	H	insecticide	Crosby	applied fenthion to backs of cattle
4	1989	M	27	H	insecticide	Terry/Lubbock	mixing operation - unspecified
5	1989	M	24	W	insecticide	Crosby	agricultural application - aerial
6	1989	M	25	W	insecticide	Hockley	agricultural application - ground
7	1989	M	31	W	insecticide	Lubbock	chewed on stem of treated cotton plant
8	1989	M	71	W	herbicide	Lubbock	exposed at chemical plant - unspecified
9	1990	M	28	H	herbicide	Hale	agricultural application - research
10	1990	M	13	H	herbicide	Hale	agricultural application
11	1990	M	55	W	insecticide	Lubbock	agricultural application
12	1990	M	29	W	herbicide	Lubbock	agricultural application - ground

* W = non-Hispanic White
H = Hispanic

reported by a physician in Gaines County. Case #2 was also identified through the hospital record review.

B. Hospital Records

Eleven cases of confirmed or suspected occupational pesticide poisonings were identified for 1989 and 1990 in the nine-county study area through the review of hospital medical records and emergency room logs. Seven cases were identified for 1989 and four cases for 1990. A total of 250 medical records and approximately 155,000 emergency room log entries were reviewed in 16 hospitals. Table 2 lists the number of records reviewed by hospital and location.

Ten of the 11 cases identified had not previously been reported to the TDH surveillance system. Case #2, described above, evidently sought treatment in a Lubbock hospital after presenting to a physician in Gaines County.

All 11 cases identified as a result of the hospital record review were male ranging in age from 13 to 71 years old. The average age was 32 years old. Two were under the age of 18 (13 and 17 years old). Four (36%) were Hispanics, the rest were non-Hispanic whites. Nine of the 11 cases (82%) were clearly related to agricultural exposure, one was probably agriculturally related, and the circumstances of one exposure were not clear. Four of the cases were self-employed farmers. None of the cases were clearly identifiable as migrant workers.

Three of the cases sought treatment in the same county as the exposure occurred, five went to hospitals out of the county. Six of the 11 cases were treated in Lubbock hospitals. For three of the cases, the exact location of the exposure was not given. The medical records indicated that four of the cases had their cholinesterase levels tested, but the results were available for only one case. This case (Case #7) was exposed to an unidentified insecticide. The medical record reported a plasma cholinesterase level of <1.1 ug/dl.

Two cases, including Case #2 listed above, involved aerial application. Case #2, a 17-year old white male, was mixing pesticides and flagging for the family crop dusting business. He presented to a physician in Gaines County, was treated in a small hospital, and the following day drove approximately 80 miles to Lubbock to seek additional treatment. The second case (Case #5) involving aerial application was a white 24-year old male who was hospitalized for three days after exposure to an unspecified insecticide. It was not clear from the medical record what specific type of activity resulted in the exposure.

Four of the cases involved self-employed farmers. Case #7 involved a 31-year old white farmer who became ill after reportedly chewing on a stem of a cotton plant recently treated with the insecticide Temik. He was admitted to the hospital for treatment. Case #6, a 25-year old white farmer, was diagnosed and treated in the emergency room for an upper respiratory infection. Review of the outpatient record from the emergency room revealed he had been applying pesticides to his crops over the course of the preceding week. Case #12, a

Table 2

Medical Records Reviewed and
Number of Cases Identified by Hospital

County	Hospital	Medical Records Reviewed	ER Log Entries Reviewed	Number of Cases
Crosby	Crosbyton Clinic Hospital	7	3650	2
Garza	Garza Memorial Hospital	0	8475	-
Floyd	Lockney General Hospital	3	830	-
Floyd	Caprock Hospital District	0	3744	-
Hale	Hi-Plains Hospital	3	4512	1
Hale	Central Plains Regional Hospital	10	12,312	1
Hockley	Methodist Hospital - Levelland	3	12,932	2
Lamb	Lamb Healthcare Center	0	3889	-
Lubbock	Highland Medical Center	4	3789	2
Lubbock	Methodist Hospital - Lubbock	103	30,075	3
Lubbock	St. Mary's of the Plains Hospital	22	20,086	-
Lubbock	South Park Medical Center	1	10,650	-
Lubbock	University Medical Center	14	25,134	-
Lubbock	West Texas Hospital	2	4587	-
Lynn	Lynn County Hospital District	2	3168	-
Terry	Brownfield Regional Medical Center	76	10,650	-

29-year old white farmer, was exposed to Round-up while using a spray rig. He was treated for eye and dermal exposure in an emergency room and released.

The fourth case of pesticide poisoning to a self-employed farmer involved possible long-term exposure. A 55-year old white farmer (Case #11) originally presented to a private physician's office for sinusitis. He later presented to the emergency room of a Lubbock hospital where he was admitted for eight days for treatment of "toxin-related liver disease." He had reported long-term exposure to various pesticides in his medical record.

Another of the cases of farm-related exposures also involved possible long-term exposure. Case #9, a 28-year old Hispanic male, was exposed to an unidentified herbicide while working for a company engaged in agricultural research. He reported wearing no respiratory protective equipment. According to the medical record, he had complained of shortness of breath and "anxiety" for a period of three weeks. During the previous six months, he had been treated for anxiety five different times and was given a prescription for an anti-anxiety medication. He reported to the emergency room after the latest exposure and was told to report to his private physician for a refill on his anti-anxiety medication.

The youngest case of occupational pesticide poisoning identified in the study was a 13-year old Hispanic male (Case #10). He was exposed to a herbicide while working with his father at a farm. He was treated and released from an emergency room.

The remaining case identified as agriculturally-related was a 29-year old Hispanic male (Case #3). He presented to a physician's office and was subsequently admitted to a hospital for five days for treatment. Over the preceding week he had been applying fenthion to the backs of cattle at the ranch where he was employed.

The oldest case identified through the study was a 71-year old white male (Case #8). He was exposed to Treflan at a chemical company. He presented to an emergency room where he was treated (eyes irrigated and bathed) and released to his home with instructions to bath again.

The final case identified during the study (Case #4) was a 27-year old Hispanic male. The information in the medical record did not detail the location of the exposure. It did indicate, however, that he was working to mix pesticides when the exposure occurred. He presented to a local clinic, but then was transferred to a larger hospital inside the study area for treatment. He was not identified at the larger hospital as a case.

C. Physician Survey

Responses to the one-page mail survey were received from 429 (64%) of the 674 physicians surveyed. Twelve of the 429 indicated they had seen at least one case of occupational pesticide poisoning in 1989 and 1990. Follow-up letters requesting additional information on each case were mailed to the 12 physicians. Each office was also contacted by phone to request the additional information. No responses were received from either the follow-up letter or the subsequent phone call. Staff at several of the offices explained that the

information requested could not be easily retrieved without the names of the individuals involved and tracking down the individuals would be too time consuming.

A secondary objective of the study was to increase the awareness of the problem of occupational pesticide poisonings and to increase the awareness of the reporting requirements of the Texas Disease Reporting Act among the health care providers in the nine-county study area. While in the study area, TDH staff met with each existing sentinel provider, physicians and clinics, to discuss pesticide poisoning reporting in general and to provide some additional written information. During the site visits to the hospitals, a meeting was held with each hospital administrator and medical records director to re-emphasize the importance of reporting and to leave some educational material. The physician mail survey also served to increase awareness of the 674 physicians in the area. As a result of the survey, the 12 physicians stating they had treated a case of occupational pesticide poisoning agreed to participate in the TDH surveillance system.

DISCUSSION

The primary objective of the study was to identify all cases of occupational pesticide poisoning in the nine-county Southern High Plains area for 1989 and 1990 and to identify barriers to reporting cases to the TDH surveillance system. Two cases of occupational pesticide poisoning were identified through the TDH surveillance system. The review of hospital medical records, both inpatient records and emergency room log books, identified 11 cases including Case #2 who had previously been reported through the surveillance system. Medical record directors had been requested to provide all inpatient records with specified ICD codes representing a wide range of illnesses and exposures potentially related to pesticides. TDH staff reviewed 250 records from the 16 hospitals in the study area with the specified codes. Of the 250 records reviewed, six cases of confirmed or suspected occupational pesticide poisoning were identified.

The remaining five cases were identified through a labor and time-intensive review of the emergency room log books of each of the 16 hospitals. The amount and quality of information available in the emergency room log entries varied dramatically with each hospital. Some recorded actual diagnoses for the patient, others recorded the patient's complaints verbatim, others recorded unusual circumstances or exposure information. The outpatient emergency room records requested for further review were selected based on some objective criteria (pesticide, chemical, or occupational exposure noted in log entry) and on some purely subjective criteria (Hispanic male with any unusual circumstance or suspicious symptoms). The emergency room logs of the smaller hospitals were generally much more descriptive in nature and allowed quicker recognition of potential cases. For the larger hospitals, the majority of the log entries provided little or no clue as to possible pesticide or chemical exposure. The five cases identified through the emergency room logs were each from smaller hospitals. Since the inpatient

records for each of the 155,000 log entries were not reviewed, it is not possible to accurately assess how many cases of occupational pesticide poisoning may not have been identified through this method.

The results clearly show that for the nine-county study area in the Southern High Plains, occupational pesticide poisoning cases were underreported for 1989 and 1990. The study also provided some insight into possible barriers to the reporting of occupational pesticide poisoning.

Working with the emergency room records and speaking with several emergency room physicians highlighted the need for physician education concerning pesticide poisoning, in general, and the occupational disease reporting requirements. Several of the emergency room physicians said they did not see any cases of pesticide poisoning and none were familiar with the occupational disease reporting requirements. One emergency room physician noted that she did see patients who "thought" they had been exposed to pesticides, but generally treated them for anxiety reactions and released them. She did not detail any attempts to include occupational history in her medical histories. It was also apparent from conversations with several private physicians and emergency room physicians that they do not believe they are seeing many cases of occupational pesticide poisoning.

Workers suffering from pesticide-related illness may not be seeking treatment in the health care system or may not be seeking treatment at all. This study was designed to target the standard health care providers and did not address potential impediments to individual workers seeking treatment.

Workers suffering from a pesticide-related illness and reaching a health care facility may encounter a physician who is not familiar with the symptoms of various types of pesticide poisonings and may not diagnose the illness as such. If the worker is not asked about the possibility of occupational exposure or does not volunteer the information, the fact that it is an occupational pesticide poisoning may go unnoticed. Routine inclusion of occupational exposures in the medical history would provide the physician with valuable diagnostic information in many cases.

In an effort to promote awareness of the problem in the health care community and to re-establish contact with the existing sentinel providers, TDH staff met personally with each physician and clinic staff currently serving as sentinel providers. TDH staff also met with each of the hospital administrators and medical record directors to emphasize the importance of reporting occupational diseases. The success of these outreach efforts will be measured over the next year by the number of cases reported through the TDH surveillance system.

The physician mail survey, in addition to providing an estimate of the number of patients seeking treatment in private offices in the study area, also may have increased the awareness of the 674 physicians in the area about the problem of pesticide poisoning and of the reporting requirements. The 12 physicians who did indicate in the survey they had seen at least one case of occupational pesticide poisoning were recruited to participate in the TDH surveillance system as sentinel providers. They will be contacted once a

month to see if they have seen any cases of occupational pesticide poisoning and to gather additional information on those cases in a timely manner.

One result of the study worth special note was the identification of three cases of occupational pesticide poisoning in minors. The youngest case reported was 13 years old. Although the number of total cases of reported occupational pesticide poisoning for the entire two years was relatively small, the identification of three cases in minors represents 25% of the total cases. Should the 25% distribution of cases among minors hold true for the rest of the state, the implications for children's health is dramatic. A study designed to target workers and specifically children of workers would be needed to fully ascertain the extent of childhood exposure to pesticides.

In summary, the results of the study in the nine-county area of the Southern High Plains growing region indicate that for 1989 and 1990, the number of occupational pesticide poisonings were underreported by at least five-fold. Based on the limited number of cases reported, the study also showed that a potential problem exists with childhood exposure to pesticides. The study also highlighted the continuing need for health care provider education on the recognition of pesticide-related illnesses and on the reporting requirements of the occupational disease reporting law. Without the active participation of the health care community, particularly physicians, the surveillance system for occupational pesticide poisoning cannot provide the information necessary to identify problems in the agricultural workforce and provide timely intervention.

RECOMMENDATIONS

The following are a list of specific recommendations designed to increase the awareness of the problem of pesticide poisonings and to increase the awareness of the reporting requirements.

1. Outreach efforts should continue to educate physicians in the recognition, diagnosis, treatment, and reporting of occupational pesticide poisoning. This may be accomplished through mailouts, journal articles, and continuing education opportunities.

2. Outreach efforts to the remainder of the medical community should continue to increase the awareness of the reporting requirements of the occupational disease reporting law in Texas. These efforts should be directed at clinic directors, nurses, hospital records directors, and other medical professionals. This may also be accomplished through mailouts of information, journal articles, and through continuing education classes.

3. Enlist the aid of local health agencies and state regulatory agencies in developing a comprehensive and effective outreach program which incorporates all aspects of pesticide regulation.

4. Continue regular contact with the existing sentinel providers, not only to receive information on new cases of pesticide poisoning, but to also provide

feedback on the effects of reporting and to supply additional educational materials.

5. Efforts to enroll new sentinel providers should continue.

6. A survey of farmworkers should be conducted in various areas of the state to obtain a more accurate estimate of the number of workers, including children, who are at risk of exposure to pesticides; the types and amounts of pesticides used in the area; and the number of workers who may have actually suffered from pesticide poisoning. This survey could also be used to assist in identifying possible barriers to seeking treatment once the worker has been exposed. This survey could be a joint effort between state and local agencies and organizations.

7. Establish an educational outreach program for workers, other than farmworkers, who are also at risk from exposure to pesticides and who are not currently targeted for such efforts. These groups may include self-employed farmers, nursery workers, and pest control operators and workers.

American Journal of Industrial Medicine 19:637–642 (1991)

Acute Occupational Respiratory Diseases in Hospital Discharge Data

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We investigated the feasibility of using hospital discharge diagnoses of ICD codes 506, 507, and 508, respiratory diseases from external sources, to identify occupational sentinel health events [SHE(O)]. Two hundred sixty-nine records were reviewed and 66 (25%) were incidents where the work-relatedness of the respiratory diseases was documented in the medical records. Twenty-six percent of the 269 records contained no exposure information. Sixty-four of the 66 occupational cases were from ICD codes 506.0–506.9, with the largest number classified as ICD codes 506.0 (bronchitis and pneumonitis due to fumes and vapors) and 506.3 (other acute and subacute respiratory conditions due to fumes and vapors). We conclude that surveillance of ICD codes in the 506 series, where 39% of the cases were secondary to occupational exposures, is a valuable component of a surveillance system for preventable occupational lung disease.

Key words: surveillance, sentinel health event, occupational respiratory disease, ICD classification

INTRODUCTION

Lung diseases are among the leading work-related diseases and injuries [Baker et al., 1988]. Acute respiratory conditions due to gases, fumes, and vapors are important components of the spectrum of occupational lung diseases [Merchant, 1986]. Surveillance is a key element in the prevention strategy for these diseases. Recently, attention has been focused on the use of hospital discharge data for occupational disease surveillance [National Research Council, 1987; Rosenman, 1988; Kipen et al., 1990].

The present study examines whether hospitalized patients with International Classification of Disease (ICD) codes in the 506, 507, and 508 series may represent sentinel health events which should be part of occupational disease surveillance systems. A sentinel health event (occupational) [SHE(O)] is defined as "a disease,

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Accepted for publication August 29, 1990.

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TABLE I. Respiratory Conditions in the 506, 507, and 508 Series*

506	Respiratory conditions due to chemical fumes & vapors
506.0	Bronchitis and pneumonitis due to fumes & vapors
506.1	Acute pulmonary edema due to fumes & vapors
506.2	Upper respiratory inflammation due to fumes & vapors
506.3	Other acute and subacute respiratory conditions due to fumes & vapors
506.4	Chronic respiratory conditions due to fumes & vapors
506.9	Unspecified respiratory conditions due to fumes & vapors
507	Pneumonitis due to solids & liquids
507.1	Due to inhalation of oils & essences
507.8	Due to other solids & liquids
508	Respiratory conditions due to other & unspecified external agents
508.8	Respiratory conditions due to other specified external agents
508.9	Respiratory conditions due to unspecified external agent

*ICD-9 CM codes.

disability, or untimely death which is occupationally related and whose occurrence may: 1) provide the impetus for epidemiologic or industrial hygiene studies; or 2) serve as a warning signal that materials substitution, engineering control, personal protection, or medical care may be required" [Rutstein et al., 1983]. Awareness of such cases may enable identification of high-risk activities, industries, or employers, and thereby, may trigger public health efforts to prevent recurrences.

MATERIALS AND METHODS

Patients, hospitalized in New Jersey during 1985 and 1986 with discharge diagnoses coded in the 506, 507, and 508 (Table I) series, were identified using hospital discharge data reported to the New Jersey State Department of Health. We excluded 507.0 (inhalation of food or vomitus) and 508.0 and 508.1 (radiation pneumonitis and fibrosis), as they are not legally reportable in New Jersey. All 105 acute care non-federal hospitals in the state are required to abstract the medical record number, hospital code, primary diagnosis and up to seven secondary diagnoses, date of admission, date of discharge, date of birth, and sex of all hospital discharges. Information on the patient's occupation or employer is not available on this computer record.

A review of complete hospital records of 50 cases from two different hospitals indicated that when information about a causal exposure was not present in the face sheet, admission history and physical examination, or discharge summary, it was not contained elsewhere in the chart. A coding instrument was thus developed for extraction and analysis of information about exposure from these components of patient records. All exposures to exogenous agents were categorized as "occupational," "non-work," "location not specified," or "no exposure information."

Hospitals were requested to furnish the New Jersey State Department of Health with a copy of the face sheet, admission history and physical examination, and discharge summary for all 1985 and 1986 discharges with reportable diagnoses in the 506, 507, and 508 series. Hospital records were abstracted and coded. When more

TABLE II. Location of Exposure for Hospitalized Patients With Acute Respiratory Conditions Due to Exogenous Agents (1985–1986)*

				Records with exposure information					
		Records with no exposure information		Occupational exposure (includes emergency responders)		Non-workplace exposure		Location not specified	
Diagnosis	Records received	No.	Percent	No.	Percent	No.	Percent	No.	Percent
506.0	101	7	(7)	35	(35)	48	(48)	11	(11)
506.1	8	2	(25)	2	(25)	4	(50)	0	
506.2	3	0		1	(33)	2	(67)	0	
506.3	36	3	(9)	20	(56)	11	(31)	2	(6)
506.4	17	6	(35)	6	(35)	2	(12)	3	(18)
506.9	1	0		0		0		1	(100)
506.0–506.9	**166**	**18**	**(11)**	**64**	**(39)**	**67**	**(40)**	**17**	**(10)**
507.1	35	28	(80)	1	(3)	6	(17)	0	
507.8	28	9	(32)	0		19	(68)	0	
508.8	32	9	(28)	1	(3)	21	(66)	1	(3)
508.9	8	3	(38)	0		5	(63)	0	
507.1–508.9[a]	**103**	**49**	**(48)**	**2**	**(2)**	**51**	**(50)**	**1**	**(1)**
Total	269	67	(25%)	66	(25%)	118	(44%)	18	(7%)

*Nos. in rows indicate actual No. of records classified in each category of follow-up or exposure information. Nos. in parentheses are percent of retrieved records for the ICD category (row). Percentages may not total 100% due to rounding off. The rows in bold face denote subtotals.
[a]Excludes 508.0 and 508.1 (radiation pneumonitis and fibrosis).

than one of the reportable discharge diagnosis under study was listed on a record, the first such code listed was used.

RESULTS

Three hundred seventy-three discharges for the specified ICDs were identified for 1985–1986. Hospital records were requested from 89 identified hospitals. Of these, 68 hospitals (76%) provided copies of 269 patient records (72%).

No exposure was mentioned in 67 (25%) of the 269 patient records reviewed. Many of these may represent incorrect ICD codes, as 507.1 included 17 aspiration pneumonias associated with stroke, lung cancer, or other significant medical illness (should be 507.0). There were also 11 "lipoid pneumonias" included in the 507.1 category; however, only one of these noted an exogenous source (30 years as a shipyard painter). Endogenous lipoid pneumonia should be coded as 516.9. ICD 507.8 similarly had 9 cases of aspiration pneumonia associated with a significant medical problem and these are more properly coded as 507.0. Similar miscodings of non-exogenous medical conditions were also present in 508.8 and 508.9, although the diagnosis of "allergic bronchospasm" without a specified allergen was frequent in these codes, and some of these could be due to identifiable exposures.

An exposure to some exogenous agent was described for the remaining 202 patients (75%), of which 66 (33% of the 202) were occupational exposures (Table II). Among the 118 (60% of the 202) non-workplace exposures, which are not considered

TABLE III. Workplace Exposures Identified in Records as Causes of Respiratory Conditions Due to Fumes and Vapors: New Jersey, 1985–1986

	Mean age (range)	Sex (%)	Chlorine	Products of combustion	Known sensitizer/ asthmatogen[a]	Unspecified	Miscellaneous
506.0 (35 cases)	37.7 (20–59)	Male-28 (80) Female-7 (20)	6	12	2[b]	4	11[c]
506.1 (2 cases)	58.5 (46–71)	Male-2 (100)	—	—	—	—	2[d]
506.2 (1 case)	39	Female (100)	—	1	—	—	—
506.3 (20 cases)	37.9 (21–61)	Male-12 (60) Female-8 (40)	3	4	2[e]	5	6[f]
506.4[g] (6 cases)	48.6 (28–62)	Male-5 (83) Female-1 (17)	—	1	—	1	4[h]
507.1 (1 case)	50	Male-1 (100)	—	—	—	—	1[j]
508.8 (1 case)	41	Male-1 (100)	—	—	—	—	1[i]
Total—66			9	18	4	10	25

[a]Based on review of Merchant [1986].
[b]Agents included ethylenediamine and polyurethane.
[c]Agents included ethylene oxide, welding fumes, bromine (2), clorox, trichloroethylene, cosmetic aerosols, hydrofluoric acid (2), sulfuric acid and nitric acid, and nitrous oxide (sic).
[d]Agents included hot tar, and unspecified fog of gas.
[e]Agents included TDI and formalin.
[f]Agents included cleaning products (2), paints (2), acid, and glue.
[g]Three of the 6 cases were actually acute bronchitis but had been miscoded at the hospital.
[h]Agents included cleaning product, PVC fumes, benzene gas, welding fumes.
[i]NH_4Cl.
[j]Paint inhalation for 30 years.

further in this report, were 16 allergic/anaphylactic reactions, 14 reactions to fumes from household cleaning products, 31 ingestion/aspiration of toxic compounds, 2 suicide attempts, 5 victims of house fires, and 6 near-drownings. In 18 (7%) cases, an exposure was noted but the location was not specified.

The proportion of cases of work-related respiratory disease due to inhalation exposures varied greatly by ICD code (Table II). The largest number of occupational reports was derived from ICD 506. In the 506 series, a total of 166 patient records was reviewed. Of these, 64 cases (39%) represented occupational exposures; 61 of the 64 were in 506.0, 506.3, and 506.4. Out of the 506 series, only 506.3 had a majority (56%) of reported occupational exposures. In contrast, one of 63 in the 507 series and one of 40 in the 508 series had workplace exposures. Table III shows demographics of cases and exposure categories for cases with occupational exposure.

DISCUSSION

The cases examined in this study demonstrate that hospital discharge data offer the opportunity for surveillance of occupational causes of acute respiratory illness and injury. The explicit cooperation of individual physicians and hospital staff is not

needed for this surveillance since the information can be obtained from routine hospital discharge data. Documentation of the public health utility of such follow-up, however, must depend on the results of more timely case follow-up with complete exposure histories. This follow-up is now underway. Timely reporting of these cases by hospitals will be necessary so that public health agencies may quickly recognize and respond to sentinel events.

On the basis of the 269 hospital records reviewed for this study, it appears that at least one 3-digit (506) ICD code has a much better yield of work-related cases than do others. It is unlikely that the 28% of cases which could not be located by the hospitals would appreciably change this finding, as non-reported cases were not concentrated by geography or level of urbanization. In particular, the 506.0, 506.3, and 506.4 codes contained many occupational case reports that clearly warranted follow-up; however, the overall 506 rate of 39% work-related cases suggests that all four digit codes in 506 should be considered sentinel occupational events. Of note was the finding of 13 occupational asthma diagnoses in the 506.3 code. Due to the lack of a unique ICD rubric, occupational asthma cannot easily be identified in hospital discharge data. Because many of the agents recorded are not well-validated asthmatogens, follow-up may lead to documentation of new risks for occupational asthma.

Rutstein et al. included only 506.0 and 506.1 on the [SHE(O)] list [Rutstein et al., 1983]; all of ICD 506 and especially ICDs 506.3 and 506.4 are important additions. The overwhelming lack of exposure data and apparent medical context of many cases in 507 and 508 suggest these are less likely to be occupational; however, follow-up with physicians and patients would be necessary to verify this suggestion. The 11 lipoid pneumonias in 507.1 and some of the 12 allergic bronchospasms in 508.8 and 508.9 might be especially worthy of further investigation.

Inadequate descriptions of exposure incidents, as well as no mention of the patient's occupation, were common in the records we reviewed. Only 5% of patient records where an occupational exposure was described met two accepted standards for clinical toxicologic assessment: identification of the causative agent and estimation of dose (at least by description of the exposure circumstances). This supports the need for heightened awareness of principles of occupational medicine and toxicology in medical training [Institute of Medicine, 1988; National Research Council, 1987]. In contrast to our previous findings for ICD codes in the 495 series [Kipen et al., 1990], apparent coding errors were about half as common for the diagnostic codes in the 506, 507, and 508 series. Coding errors were far less prevalent in the 506 (11%) series than in the 507 and 508 series (48%).

We believe that surveillance of hospital discharge diagnoses in the 506 series offers a valuable avenue for identification of acute work-related respiratory disease. Based on the preliminary results of this paper, the New Jersey Department of Health has instituted rapid investigation of ICD 506 cases, including telephone interviews with patients and industrial hygiene follow-up as appropriate. The overall preventability of these cases will be ascertained upon completion of this in-depth follow-up. State health departments with timely access to hospital discharge data and existing occupational disease surveillance systems such as those funded by NIOSH for "Sentinel Event Notification Systems for Occupational Risks" (SENSOR), will find these data a useful addition to their surveillance efforts [Baker, 1989].

ACKNOWLEDGMENTS

We would like to acknowledge Rukmani Ramaprasad for help in accessing hospital discharge data and Patricia A. Hutty for expert secretarial assistance.

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Confined-Space Fatalities—Surveillance and Prevention

Fatalities associated with confined spaces are not new. The Occupational Safety and Health Administration (OSHA) addresses safety in confined spaces in many different sections of the General Industry and Construction Safety and Health Standards. In addition, OSHA is planning to promulgate a confined-space standard as a General Industry Standard. However, these standards do not apply to small businesses and municipalities. Yet, these employers continue to see a large number of confined-space fatalities.

The American National Standards Institute (ANSI) also addresses the hazards associated with confined spaces in its recently revised standard. However, not all risk factors are addressed; some are only contained in broad ANSI standards not specific to work in confined spaces.

The National Institute for Occupational Safety and Health (NIOSH) defines a confined space as an area that, by design, has limited openings for entry or exit, has unfavorable natural ventilation that could contain or produce dangerous air contaminants, and that is not intended for continuous employee occupancy. Confined spaces include tunnels, manholes, utility vaults, storage tanks, and silos.

Confined space-related fatalities present a unique occupational safety problem: death can result from many different causes such as asphyxiation, inhalation of toxic gases, drowning, or falling.

Workers from many different occupations and industries are at risk because they may enter confined spaces to perform work-related tasks, unaware that they are entering a potentially hazardous work environment.

Project FACE

NIOSH investigates selected workplace fatalities through the Fatal Accident Circumstances and Epidemiology (FACE) project. The FACE project is designed to collect descriptive data on selected work-related deaths by studying and evaluating 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.

The on-site investigations conducted by NIOSH are for research purposes only, and are not intended to determine culpability or compliance with OSHA standards.

The FACE project serves as a passive surveillance system, which relies on cooperative notification to identify workplace deaths for conducting on-site fatality investigations. There is no method for monitoring notification—it is voluntary.

Confined space-related fatalities are included in the FACE project for two reasons. First, many confined-space fatal-

Figure 1. Task Distribution of 88 Fatalities

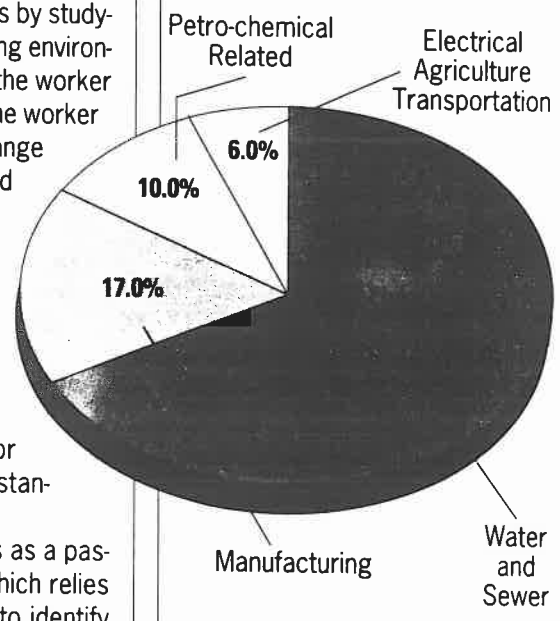
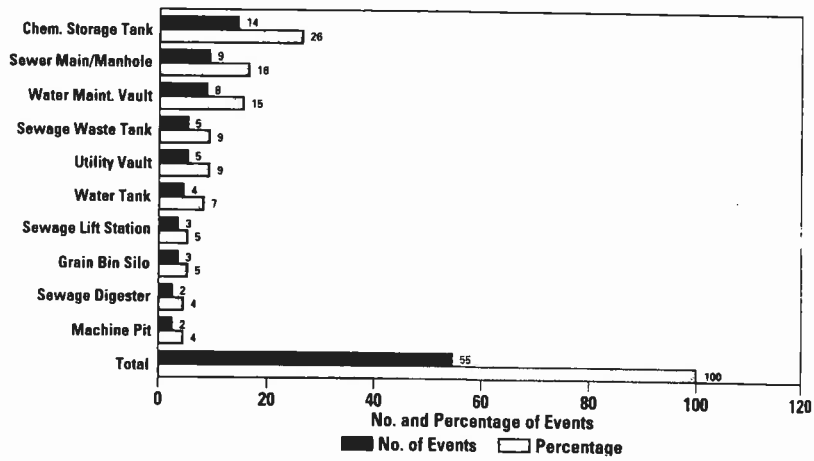


Figure 2. Type of Confined Space



ity events involve the death of more than one worker. Second, confined space-related fatalities often involve employers with 10 or fewer employees, or municipalities that do not fall under state or federal OSHA plans.

NIOSH investigators conduct on-site investigations depending on the circumstances of each event. Interviews are conducted in person with company officials and co-workers to obtain environmental and personal characteristics data.

Environmental data include information on the workplace conditions, company safety policy, and employee training. Other sources of information such as reports from medical examiners, OSHA compliance officers, police and fire department, and emergency medical services are also used.

Project Findings

NIOSH investigated 55 confined-space events resulting in 88 worker deaths. The victims (all men) ranged in age from 15 to 73 years. The mean age was 35 years.

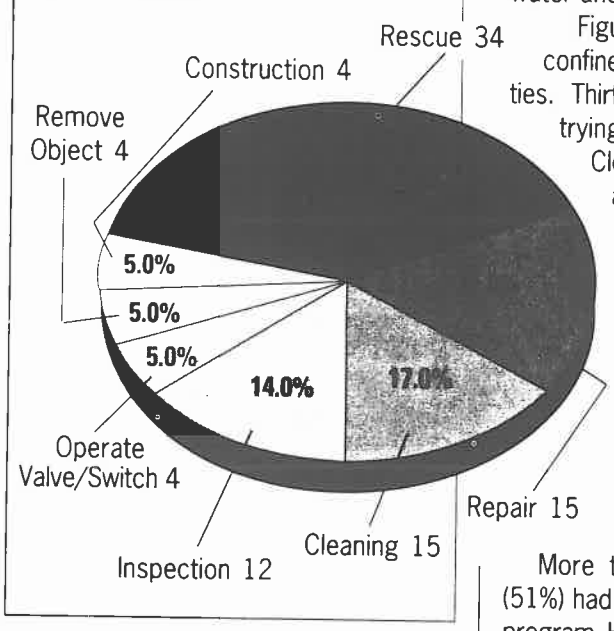
The industries that experienced one or more of the confined-space fatalities were municipal water and wastewater services; repair services (mostly tank, septic tank, and sewer cleaning and repair); construction (mostly water system and sewerage construction); manufacturing (nonchemical); agriculture (mostly family owned farms); electric utilities; and transportation (trucking).

Figure 1 shows that out of 88 fatalities, 67% were engaged in activities relating to water system, wastewater system, and sewerage construction and maintenance. Thirty-five percent were workers with supervisory responsibilities.

Characteristics of the confined space were evaluated to see if a pattern existed. The type of confined space—its size, shape, and access opening—may affect entry, emergency exit, and rescue potential (Figure 2).

In the 55 events investigated in the FACE project, confined-space openings were either round (55%) or rectangular (45%), and 38% of the openings were

Figure 3. Reasons For 88 Fatalities



less than 23 in. across. Rescue efforts in 16% of the events were hampered because of this small opening size.

The material inside a confined space can often be associated with the potential hazards of the confined-space environment. Forty-four and twenty-two percent of the confined spaces investigated contained wastewater and water, respectively.

Figure 3 shows the reasons for confined-space entry in the 88 fatalities. Thirty-nine percent were workers trying to rescue other workers. Cleaning, repair, and inspection accounted for 17%, 17%, and 14%, respectively.

Organization and safety policies of the companies with fatalities were also considered. Company size varied from 1 employee to 14,000. However, 77% of the companies had fewer than 100 employees, and 33% had 10 or fewer.

More than half of all companies (51%) had some type of written safety program. However, only 27% had a written policy for confined-space entry, and only six companies had written confined-space rescue procedures. Of these written policies or procedures, none were implemented at the time of the accidents. In only three events had workers received any confined-space safety training; in these events two supervisors and two workers died, three of whom had received the training. From the investigations, NIOSH found that none of its recommendations for confined-space entry were completely and accurately followed.

Cleaning, repair, and inspection activities led to 42 out of 88 confined-space fatalities investigated by NIOSH.

Confined-space fatality research by

Safe Work Procedures for Confined-Space Entry

- Determine whether confined-space entry is necessary to complete the assigned task.
- Confined spaces should be entered only with an approved permit.
- The confined-space atmosphere should be tested and monitored for oxygen levels and the presence of toxic and flammable gases or vapors before entry and during work.
- The confined space should be ventilated before entry and during work.
- Protective clothing, body harness, hoisting apparatus, NIOSH/MSHA-approved respirators, and other appropriate safety equipment should be used as needed.
- The confined space should be isolated from electrical or mechanical hazards where possible by lockout/tag out.
- Workers should be trained to identify confined spaces and their hazards, and also trained on the proper use of personal protection equipment.
- Warning signs should be posted near confined-space entrances/work sites.
- Medical surveillance of workers exposed to confined-space hazards should be increased.
- Standby rescue procedures should be established.
- A comprehensive written policy should be developed for all aspects of confined-space safety including entry, monitoring, emergency rescue procedures, and management commitment to the established policy.

NIOSH suggests that there are three underlying factors common to most of these deaths:

- Failure to recognize the hazards associated with confined spaces.
- Failure to follow existing, known procedures for safe confined-space entry.
- Incorrect emergency response. These data substantiate previous findings that confined-space fatalities occur because confined-space entry procedures are either not developed, are inadequate, or are not being implemented.

Confined space-related fatalities present a unique occupational safety problem: death can result from many different causes...

NIOSH urges municipalities, companies, trade associations, and unions to recognize the dangers associated with confined spaces, to work toward implementing non-entry methods of accomplishing confined space-related tasks, and to follow NIOSH recommendations for safe confined-space entry.

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Excerpted from original article that appeared in the Journal of Safety Research, *Winter 1990.*

Asbestos-Related Lung Disease In Massachusetts Workers 1982 - 1987

Bureau of Health Statistics, Research and Evaluation
Massachusetts Department of Public Health

June 1991

The Commonwealth of Massachusetts
Executive Office of Human Services
Department of Public Health

William F. Weld, Governor
David P. Forsberg, Secretary, Executive Office of Human Services
David H. Mulligan, Commissioner, Department of Public Health

ASBESTOS-RELATED LUNG DISEASE IN MASSACHUSETTS WORKERS, 1982-1987

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ACKNOWLEDGEMENTS

Asbestos-Related Lung Disease in Massachusetts Workers, 1982-1987 is based on research conducted by Benjamin Kligler, M.D., M.P.H., under contract with the Department of Public Health. The report was prepared by Letitia Davis, Sc.D. and Terry Martin, M.P.H. of the Occupational Health Surveillance Program in the Bureau of Health Statistics, Research and Evaluation. An earlier version, upon which the current report is based, was prepared by Cynthia Barber, M.P.H., Daniel Brooks, M.P.H. and Alan Geller, R.N. We would like to thank Richard Clapp, Sc.D. and Donna Spiegelman, Sc.D. for their substantial contributions to this project.

The research summarized in this report was supported in part by funds provided by the National Institute for Occupational Safety and Health.

Cover photograph: Asbestos cement worker with inadequate respiratory protection and unprotected bystander (Courtesy of Dr. Irving Selikoff, Mount Sinai School of Medicine, New York, NY)

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THE PROBLEM

The tragic story of the use of asbestos and the diseases it has caused is well known: despite early evidence of its dangers, asbestos was used extensively in this country from the 1930's to the 1970's, when workplace exposures to asbestos were finally restricted by law.[1] Few, if any, precautions were taken to protect workers during this period. Workers in many of the leading industries, including shipbuilding, construction and textiles, were exposed to dangerously high levels of asbestos. Since 1960, it is estimated that as many as 6,000-8,000 Americans have died each year from workplace exposure to asbestos fibers.[2] These numbers have gradually risen in the past 25 years and will continue to rise for at least another decade; it is estimated that as many as 300,000-400,000 Americans will have died from asbestos-related disease by the year 2010.[2]

Asbestos causes several different diseases including: asbestosis, mesothelioma, lung cancer, and digestive cancers. There is usually a long lag time - 15 to 40 years - between initial asbestos exposure and the onset of the diseases caused by it. The cases of asbestos-related disease seen today, such as those documented in this report, are due to exposures in the past.

Unfortunately, the problem of asbestos exposure in the workplace is far from over. Many workers continue to be exposed. The Occupational Safety and Health Administration (OSHA) estimates that currently between one and two million workers in the United States are potentially exposed to asbestos in construction, manufacturing and maintenance work.[3] While most new uses of asbestos in the United States are being phased out,[4] its presence in existing buildings and ships poses a continuing occupational health problem and raises concern about asbestos related-disease, disability, and death in the future.

People who work directly with asbestos clearly have the heaviest exposures, and this report focuses solely on the problem of asbestos exposure in the workplace. Asbestos exposures, however, are not limited to the workplace. The public at large is also at risk. Asbestos from a variety of sources such as the wearing away of asbestos brake linings, illegal asbestos dumping, and asbestos manufacturing processes has contaminated the ambient environment. Of greatest concern are in-place asbestos insulation and building materials in homes, schools and other public buildings. When this asbestos is disturbed or deteriorates and becomes airborne, it poses a health hazard. The adequate control and removal of asbestos in buildings remains a significant public health problem that will be with us for years to come.

MASSACHUSETTS WORKERS AT RISK

Asbestos first came into widespread use in the United States in the 1930's. Asbestos is extremely resistent to heat and chemical corrosion and was used extensively in insulation materials and as a flame retardant. It was also used in textiles, friction products such as brake linings and clutch pads, and for reinforcement in construction materials such as concrete, asphalt shingles, drain pipes and floor tiles. Workers who produced these materials and who used them in other industries were potentially exposed to dangerous levels of asbestos.

In Massachusetts, asbestos-containing materials were used extensively in two major industries - shipbuilding and construction. Asbestos was also employed in manufacturing textiles and a variety of other products, such as automobile brake linings. At present, the most hazardous asbestos exposures probably occur in repair and demolition of buildings and ships and in various maintenance jobs where exposure may be unsuspected by the worker.[5]

Shipbuilding

Asbestos had a number of uses in shipbuilding. It was applied throughout the ship's hull as insulation. It was also used to cover pipes and boilers. Insulation workers had the most direct exposure, but welders, electricians, pipefitters, boilermakers, and laborers among others were all exposed to asbestos fibers.

At its peak in 1943, the Massachusetts shipbuilding industry employed 70,000 men and women. Throughout the course of World War II, it is estimated that as many as 200,000 individuals worked at some point in Massachusetts shipyards, where they were potentially exposed to very high levels of asbestos fibers. As many as 100,000 workers may have been exposed to asbestos in the shipyards during the 1950's and 1960's when 7,000 to 10,000 workers were employed in shipbuilding at any one time.[6] The Massachusetts shipbuilding industry has declined to about 1,200 workers in 1991.[7] Repair work still ongoing in older ships poses a continuing danger of asbestos exposure to current workers.

> *Asbestos was brought into the ship's engine room in large burlap bags, often as many as six bags at once, each containing strips about 5 feet wide and 45 feet long. Strips were placed in a large mortar pit and wetted with water. Before the insulation was wetted, it would flake exposing all workers in the area to asbestos dust. ...Although asbestos was most common in the engine room, its presence was everywhere - even peeling off the walls in the lunch room. Without knowledge of the health effects of asbestos, welders would drape large asbestos strips around themselves for protection from the cold as they worked. Sometimes workers, unaware of the hazard, would roll up asbestos and use it for snowball fights...*
>
> From interview with several retired Massachusetts shipyard workers

Construction

The construction industry in Massachusetts experienced a steady boom after World War II, when it rose from 71,000 workers in 1947 to 123,000 in 1986.[8] Even with the present decline in the economy, there are still over 76,000 Massachusetts construction workers.[9] Pipecoverers (insulators), plumbers, pipefitters, carpenters, sheetmetal workers, masons, laborers, and other construction workers have all had potential exposures to asbestos in a variety of construction materials such as pipe coverings, concrete, insulation sidings, floor coverings, roofing materials and asbestos sprayed on as a flame retardant. While most new construction materials no longer contain asbestos, today's construction workers continue to be exposed through the removal of old asbestos and through incidental disturbances of asbestos in older buildings. Electricians and plumbers, for example, when installing or repairing equipment, often have to strip old asbestos from pipes, beams, and wires.

Manufacturing

Many different asbestos-containing products have at some point been manufactured in Massachusetts. These range from textiles and construction materials to brake parts, paper and cigarette filters.[10] Examples of asbestos products manufactured in Massachusetts during just one year at the height of asbestos use are listed in Table 1. In the 1940's and 1950's, over 4,000 Massachusetts workers each year were employed in the manufacture of asbestos products. Thousands more workers may have been exposed through the use of these products in their work; automobile mechanics who install or repair brake linings are just one example. Even today, several hundred Massachusetts workers are employed in making products which contain asbestos, including asbestos cement products.[11]

Table 1. Massachusetts Industries Engaged in Manufacturing Products Involving Asbestos (1957)

Asbestos cement products: siding, pressure pipe, conduits, ducts, etc.	Mattresses, asbestos
Asbestos products: except steam and other packing gaskets	Millboard, asbestos
Blankets, insulating for aircraft: asbestos	Oil seals, asbestos
Boiler covering (heat insulating material), except felt	Paper, asbestos
Brake lining, asbestos	Pipe and boiler covering, except felt
Brake lining, sintered metal and ceramic materials	Pipe covering (insulation), laminated asbestos paper
Building materials, asbestos: except asbestos paper	Pipe, pressure: asbestos cement
Carded fiber, asbestos	Roofing, asbestos felt roll
Cloth, asbestos	Rope, asbestos
Clutch facings, asbestos	Sheet, asbestos cement: flat or corrugated
Cord, asbestos	Shingles, asbestos cement
Felt, woven amosite: asbestos	Siding, asbestos cement
Floor tile, asphalt	Table pads and padding, asbestos
Friction materials, asbestos: woven	Tape, asbestos
Gaskets, asbestos	Textiles, asbestos: except packing
Grease seals, asbestos	Thread, asbestos
Insulation, molded asbestos	Tile, vinyl asbestos
Insulating materials for boilers and pipes	Tubing, asbestos
	Wick, asbestos
	Yarn, asbestos

From: Massachusetts Division of Employment Security

Other Industries: Asbestos In-place

Also potentially at risk are workers employed in buildings where asbestos was used in the insulation or building materials. If this in-place asbestos is in good condition, it does not pose an immediate hazard. However, when it is disturbed or damaged fibers can become airborne and place workers at risk. Several studies have documented asbestos-related disease among building custodians[12-15] who are likely to have relatively high exposures compared to building occupants such as office workers and teachers. The risk posed by long term occupational exposure to low levels of asbestos fibers in buildings has not been well studied.

Asbestos Abatement

Today an entire new industry - asbestos abatement - has developed to deal with the problem of asbestos in buildings. Massachusetts law requires asbestos abatement contractors to be licensed. All asbestos abatement workers must be certified. Approximately 250 contractors have been licensed by the Massachusetts Department of Labor and Industries since the program began in 1988. Over 10,000 asbestos abatement workers have been certified.[16] These workers must be trained and follow prescribed methods in handling asbestos. Asbestos abatement, however, remains a high risk job. Given the long lag between asbestos exposure and the diseases it causes - usually 15-40 years - the health impact of current asbestos exposures on these workers will not be known for decades.

LUNG DISEASES CAUSED BY ASBESTOS

This report focuses on three lung diseases caused by asbestos: asbestosis, a scarring of the lung tissue; mesothelioma, a cancer of the lining of the lung and abdominal cavity; and lung cancer (see Table 2).[17] Asbestosis, which makes breathing progressively more difficult and can lead to death, is caused only by exposure to asbestos. Mesothelioma, a very rare and fatal cancer, is believed to be related to asbestos exposure in at least 66-80% of the cases.[18] It is difficult to determine how much lung cancer is caused by asbestos because there are many other causes of lung cancer such as smoking and other occupational exposures. However, because it is a much more common disease, more people die of lung cancer caused by asbestos than either mesothelioma or asbestosis. It has been estimated that for every case of mesothelioma caused by asbestos, there are three cases of asbestos-related lung cancer.[19]

The risk of developing asbestosis increases with increasing exposure (level and duration) to asbestos fibers. Severe, disabling asbestosis is caused by heavy exposures; lower exposures can cause less severe scarring of the lung seen on x-ray which may or may not be accompanied by symptoms such as coughing and shortness of breath. The risk of lung cancer also increases with increasing asbestos exposure and is multiplied among workers who also smoke. Even low levels of asbestos exposure have been associated with mesothelioma. For example, mesothelioma has been found among family members of workers who brought asbestos home on their clothing.[20]

Asbestos has also been linked to a number of other diseases, including cancers of the larynx and the digestive system and the condition known as "pleural plaques." These are not addressed in this report.

Table 2. Asbestos-Related Lung Diseases: Some Basic Facts

	Mesothelioma	Lung Cancer	Asbestosis
Disease Definition	Cancer of the lining of lung, abdominal cavities	Cancer of the lung, bronchus, or trachea	Scarring of lung tissue in response to build-up of asbestos fibers in lung
Symptoms	One-sided chest pain, loss of appetite, fatigue, shortness of breath, weight loss	Cough, blood in sputum, shortness of breath, weight loss, fatigue, weakness, difficulty swallowing, loss of appetite, hoarseness	Shortness of breath on exertion progressing to shortness of breath at rest, tightness in chest, chronic cough
Lag Time	15-60 yrs, usually 35-40	20-50 years	5-40 years depending on exposure level
Prognosis	Poor; average survival less than 18 months	Poor; 5 year survival is only 13%	Can be fatal, disease may progress without further asbestos exposure
Est. % due to asbestos	At least 66-80%	7%	100%
Est. # cases/yr in Mass. due to asbestos	At least 40-50	At least 120-150	At least 25
Other causes	None known; smoking is not related	Smoking, other occupational exposures including arsenic and chromium	None

PURPOSE OF THIS REPORT

The purpose of this surveillance report is to describe patterns of mesothelioma, lung cancer and asbestosis among Massachusetts workers during 1982-1987. Cancer registry and death certificate data, routinely collected by the Department of Public Health, are used to document these diseases in industrial and occupational groups. The report provides information *specific to Massachusetts* about asbestos-related diseases in groups of workers already known to be at high risk, such as shipyard workers. It also generates new leads about other groups who may be at risk due to asbestos exposures in the past.

METHODS

The technical document entitled ***Asbestos-Related Respiratory Disease among Massachusetts Workers, 1982-1987*** contains a detailed explanation of the methods used in the study upon which this report is based.*

Sources of Information

Mesothelioma and Lung Cancer: Massachusetts Cancer Registry

Asbestosis: Massachusetts Death Certificates

Information about the actual asbestos exposures of individuals was not available for this analysis. However, both death certificates and cancer registry reports contain information about the usual occupation and usual industry of disease victims. This information was used as an indicator of potential asbestos exposure in this surveillance study.

Time Period

1982-1987: the first six years for which complete Massachusetts Cancer Registry data were available.

Cases Included in the Study

Mesothelioma and Lung Cancer: All individuals with mesothelioma (pleural and peritoneal) or lung cancer, 20 years or older, diagnosed during 1982-1987 and reported to the Cancer Registry. Information about occupation or industry was missing for approximately 40% of the cancer cases. These cases were excluded from the analysis.

Asbestosis: All individuals who died in Massachusetts from 1982-1987 for whom asbestosis was listed on the death certificate as either the underlying or a contributing cause of death. Occupation or industry information was reported on 99% of the records.

Cases were grouped by occupation and by industry for the analysis.

* Available from the Massachusetts Department of Public Health, Bureau of Health Statistics, Research and Evaluation.

Measures of Disease

Mesothelioma and Lung Cancer: Standardized Morbidity Odds Ratios (SMOR's)[21]

SMOR's were calculated to measure the association between mesothelioma or lung cancer and employment in selected occupation and industry groups. An SMOR for a given occupation or industry group can be interpreted as the observed number of cancer cases in that group divided by the number expected based on the cancer experience of a statewide standard population.* An SMOR greater then 1.00 indicates that the group's incidence of mesothelioma or lung cancer is greater than expected based upon statewide incidence, whereas a SMOR less than 1.00 indicates that the observed number of cases is less than expected. For example, an SMOR of 2.00 indicates that there are twice as many cancer cases as expected.

SMOR's for mesothelioma were computed for all occupation and industry groups with five or more cases of mesothelioma. Since mesothelioma is a sentinel for or sign of asbestos exposure, SMOR's for lung cancer were computed for these same groups. Lung cancer was also examined in several other industries and occupations which were believed to have potential asbestos exposure. All SMOR's were computed taking age and gender into account.

Statistically significant associations (where the 95% confidence interval did not include 1.00) for mesothelioma and lung cancer are presented in the Results section of this report. It should be noted that although statistical significance means that an association is not likely due to chance, it does not necessarily imply a causal relationship. For example, in the case of lung cancer, an observed association could be due to other factors (e.g. smoking or other workplace exposures) rather than asbestos. Furthermore, it is not known whether the individual workers were exposed to asbestos in the job listed as their usual occupation. Other considerations in interpreting these findings are the magnitude of the cancer risk (e.g. a larger cancer excess is more suggestive of a causal association than a smaller excess) as well as the consistency with the findings of other studies.

Asbestosis: Numbers of asbestosis cases

Massachusetts death certificates are the best available, although limited, source of information about asbestosis cases in the state. Asbestosis is not always fatal and is not necessarily listed on the death certificates of individuals who have the disease but die of other causes. The true number of people who have died with asbestosis is undoubtedly far greater than the number with asbestosis reported on their death certificates.

Because asbestosis is underreported on death certificates and factors influencing reporting are not well understood, it was not possible to compute specific measures of asbestosis risk. As an alternative, this report simply lists numbers of asbestosis cases by occupation and industry group to document the existence of asbestosis in the state. Numbers of cases are presented for each occupation and industry group with elevated risk of lung cancer or mesothelioma.

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* Construction and shipbuilding workers, previously found to have excess asbestos-related cancers in Massachusetts, were excluded from the standard population.

Data Limitations

The data upon which this surveillance study is based are limited in a number of ways. For example, usual occupation and industry are only indicators of actual exposure and only capture part of a person's work experience. Information about other factors which cause lung disease, with the exception of limited smoking data reported to the Cancer Registry, was not available. Missing occupation and industry information in the Cancer Registry is a potential problem. If the likelihood of reporting specific occupations or industries is related to specific cancer sites, the SMOR's in this study could be incorrect. There is little reason to believe this occurs. One possible exception is that the well-known association between mesothelioma and shipbuilding prompts people to record shipbuilding more often for mesothelioma cases than for other cancers. If this occurs, the SMOR's for mesothelioma among shipbuilders are overestimates. The inadequacy of the asbestosis data have been discussed.

In spite of these limitations, the data are generally considered adequate for surveillance purposes. The findings alone do not provide evidence of a causal relationship but should be taken together with results of previous studies and with what is known about asbestos exposures in the workplace. Since asbestos-related diseases have been studied extensively, many of the findings in this study highlight well-documented associations. Other findings are suggestive of industries and occupations where asbestos may have been used in the past.

RESULTS

Mesothelioma

There were a total of 365 cases of mesothelioma reported to the Massachusetts Cancer Registry from 1982-1987.

Industries at Risk:

Industry information was available for 205 (56%) of the mesothelioma cases.

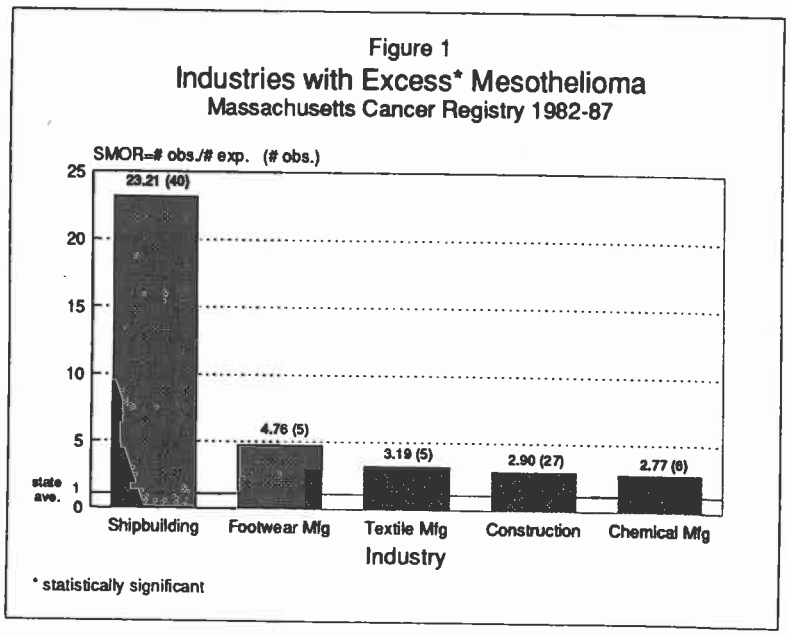
-- **Shipbuilding** workers were over 20 times* more likely to develop mesothelioma than the standard population (40 observed cases, 2 expected).

-- **Construction** workers had about a three-fold risk compared to the standard population (27 observed, 9 expected).

-- **Textile and chemical manufacturing** workers also had three-fold risks of mesothelioma.

-- **Footwear manufacturing** workers were almost five times more likely to develop mesothelioma than the standard population (5 observed, 1 expected).

Comments: The observed excesses of mesothelioma among workers in the shipbuilding, construction and textile industries are consistent with findings in numerous studies and with well-documented asbestos exposures in these industries. Excess mesothelioma in the chemical industry has been observed in at least one other study[22] and asbestos was used extensively as insulation on piping systems and tanks in some large chemical plants.[23] There are several case reports of mesothelioma among workers in the footwear industry.[24] Asbestos may have been used as a filler in rubber soles or been present in talc used as a mold release.[25]



* It is possible that the observed excess in shipbuilding somewhat overestimates the true excess because awareness of this well-known association may have prompted increased reporting of this industry for mesothelioma cases.

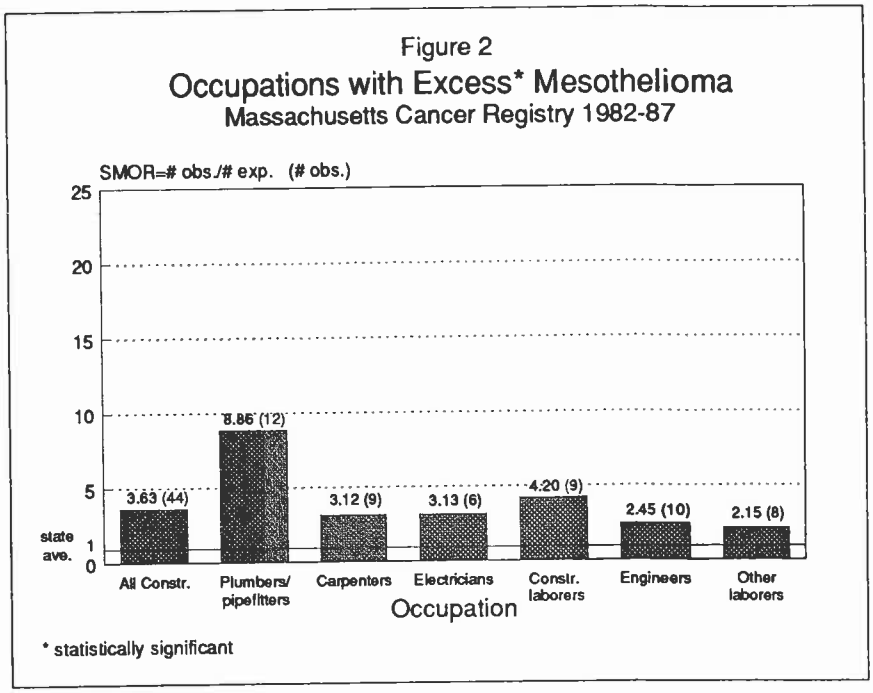
Mesothelioma

Occupations at Risk:

Occupational information was available for 224 (61%) of the mesothelioma cases.

- All **construction trades** combined had an elevated risk of mesothelioma. Some of these workers may have been employed in shipyards.
  - **Plumbers and pipefitters** were nine times more likely to develop mesothelioma than the standard population (12 observed, 1 expected).
  - **Carpenters, electricians, and construction laborers** were also at increased risk.
- **Engineers and "other laborers"** each had a two-fold risk of mesothelioma.

Comments: Excess mesothelioma has repeatedly been observed among construction trades workers employed within the shipbuilding and general construction industries. Due to limited data in this study, it was not possible to adequately determine the specific industries in which construction trades workers were employed. Many may have worked in both the shipbuilding and general construction industries.



Lung Cancer

Industries at Risk:

Industry information was available for 9,116 (42%) of the lung cancer cases.

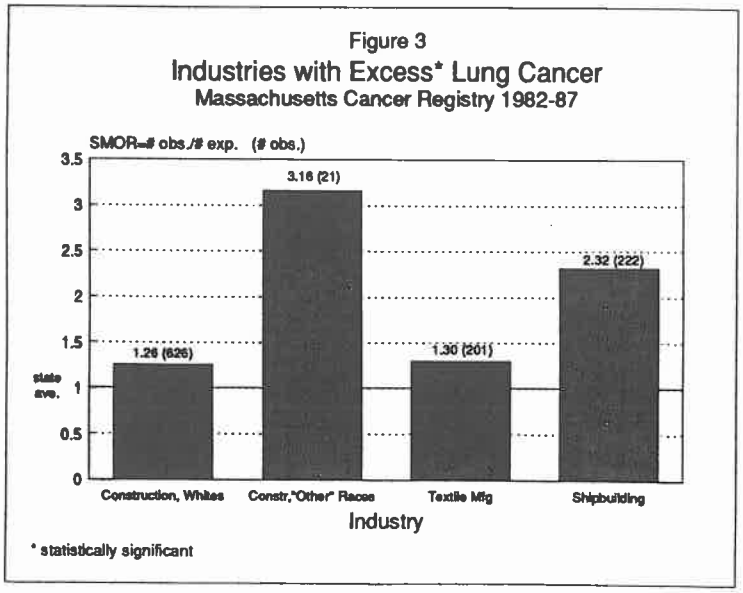
-- **Shipyard** workers were more than twice as likely to develop lung cancer as the standard population (222 observed, 96 expected)

-- White **construction** workers had a small excess of lung cancer; those of "other" races (except blacks) were more then three times as likely to develop lung cancer as the standard population.**

-- **Textile manufacturing** workers also had increased lung cancer risk (201 observed, 154 expected).

Comments: The findings for lung cancer are difficult to interpret because there are other well-known risk factors for lung cancer, most notably cigarette smoking. However, further analysis using limited smoking data available in the Cancer Registry revealed that differences in smoking patterns between industry groups accounted for only a small proportion of the excesses. Increased risks of lung cancer among workers in the shipbuilding, construction and textile industries are consistent with previous reports and with the observed excesses of mesothelioma, a sentinel for asbestos exposure, in these same industries in Massachusetts. The finding of greater excess among construction workers of "other races" (and blacks) is noteworthy given mounting evidence that minority workers are disproportionately exposed to occupational hazards.[26] Marked excesses of lung cancer among these workers remained after taking smoking into account.

It is important to note that because lung cancer is so much more common than mesothelioma, the smaller SMOR's for lung cancer actually represent much larger numbers of cases potentially caused by asbestos.



** Black construction workers also had excess lung cancer (20 observed cases, 11 expected), but this finding was not statistically significant and is not included in Figure 3.

Lung Cancer

Occupations at Risk:

Occupational information was available for 11,812 (54%) of the lung cancer cases.

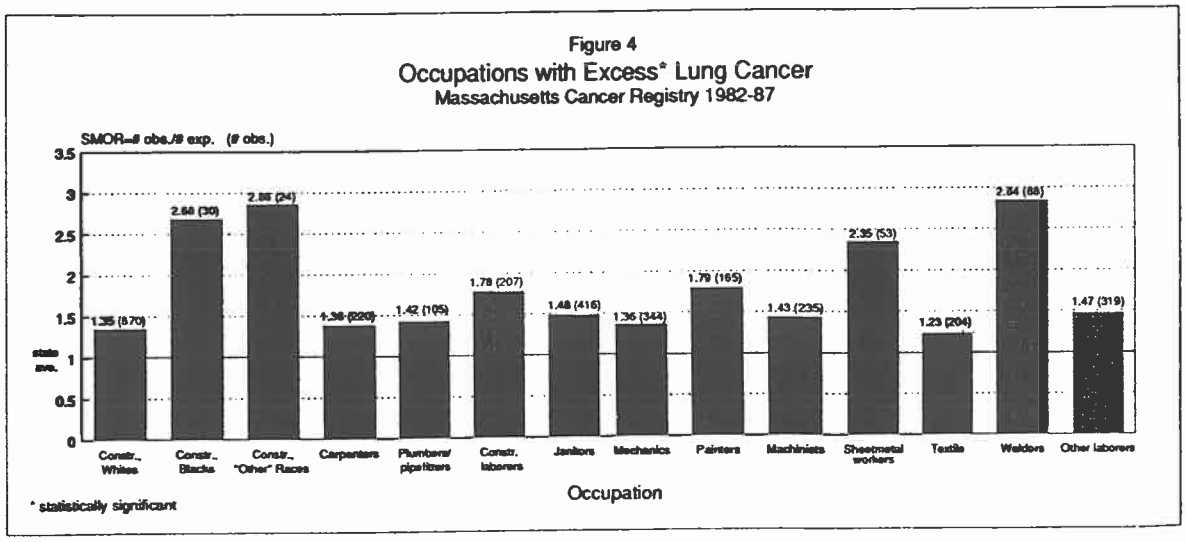
-- All white **construction trades workers** combined had a small increased risk of lung cancer. Blacks and other races were more than twice as likely to develop lung cancer as the standard populations. A number of specific construction occupations had elevated risks: **carpenters, plumbers and pipefitters, and construction laborers.**

-- **Welders and sheetmetal workers** had over two-fold risks of lung cancer.

-- **Janitors** and **mechanics** were each approximately one-and-a-half times more likely to develop lung cancer than the standard population.

Comments: All of these occupational groups are potentially exposed to asbestos. The extent to which lung cancer excesses in these groups are due to asbestos or other occupational and lifestyle factors is not known. However, findings were similar when smoking data were taken into account suggesting that all of the observed excesses were not due to differences in smoking habits.

Welders may be exposed to other carcinogens in welding fumes and have been repeatedly shown to have excess lung cancer.[27] Sheetmetal workers are frequently exposed to asbestos and in one study of Massachusetts sheetmetal workers more than half of those examined had chest x-ray evidence of asbestos-related disease.[28] The finding of increased lung cancer in janitors is notable given recent reports of asbestos-related disease among building maintenance workers.[12-15] The mechanic group includes auto mechanics who may have been exposed to asbestos in brake and clutch repair work. A number of mesothelioma cases have been reported previously among brake mechanics.[29]



Asbestosis

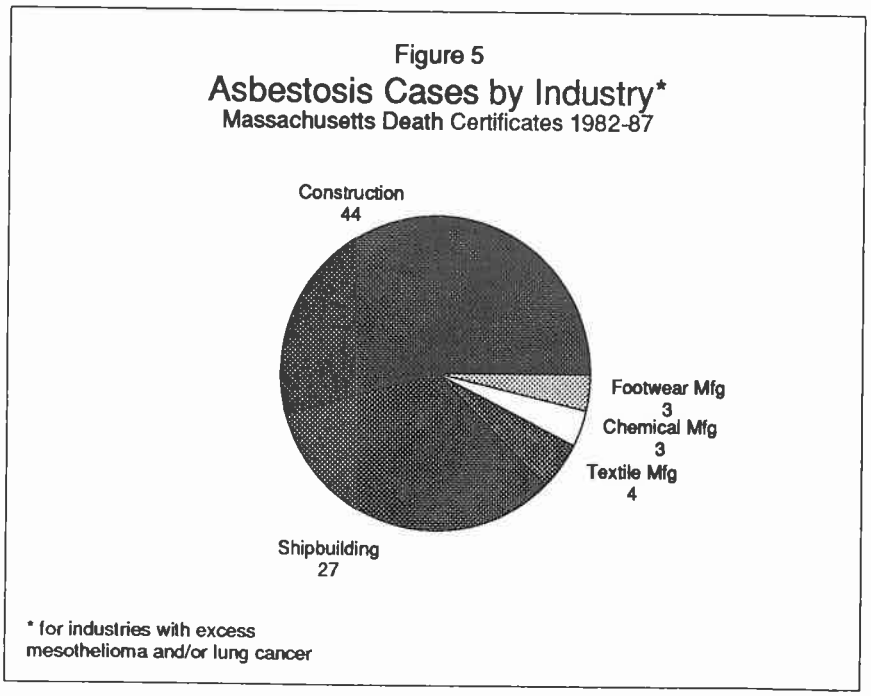
There were 163 cases of asbestosis reported on death certificates during 1982-1987 (49 as underlying and 114 as contributing cause of death). The numbers of asbestosis cases for industry or occupation groups with elevated SMOR's for mesothelioma or lung cancer are presented in the figures below. These numbers underestimate the true number of people in these industries and occupations who died with asbestosis during this time period. Large numbers in one category may reflect not only the distribution of workers at risk in these industries and occupations but also the likelihood of medical screening for asbestosis among certain high risk groups. Numbers should be interpreted as evidence of disease in these categories but not as quantitative estimates of risk.

Industries at Risk:

Industry was reported for 155 (95%) of the cases.

-- **Construction and shipbuilding** - accounted for the majority of asbestosis cases reported on death certificates, with 44 and 27 cases, respectively.

-- **Textile, chemical and footwear manufacturing** - had four, three, and three reported asbestosis cases, respectively.



Asbestosis

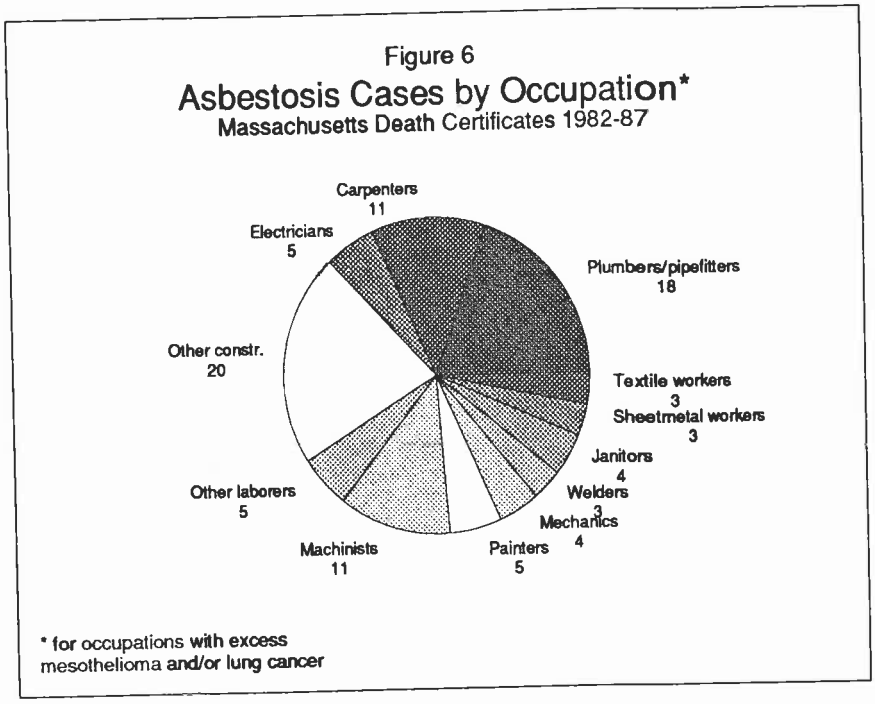
Occupations at Risk:

Occupations were reported for 160 (98%) of the cases.

-- **Construction trades** were the most frequently reported occupations of asbestosis cases (54 cases). Of these, there were 18 **plumbers and pipefitters** and 11 **carpenters**, 5 **electricians**, and 6 **construction laborers**.

-- **Machinists** accounted for 11 cases of asbestosis.

-- **Painters, mechanics, welders and janitors** accounted for five, four, three, and four asbestosis cases, respectively.



Summary

Results for all three diseases are summarized in Tables 3 and 4 to illustrate the consistency of the findings across industry and occupation groups. The findings of both excess mesothelioma and asbestosis cases in the footwear and chemical manufacturing industries are of interest given that asbestos-related diseases have not been extensively documented in these groups.

Table 3. Massachusetts Industries at Increased Risk for Mesothelioma and/or Lung Cancer

	Mesothelioma		Lung Cancer		Asbestosis
Industry	# of Cases	SMOR	# of Cases	SMOR	# of Cases
Shipbuilding	40	23.21	222	2.32	27
Construction	27	2.90	626	1.26 (whites)	44
			21	3.16 ("other" males)	
Textile Manuf.	5	3.19	201	1.30	4
Footwear Manuf.	5	4.76	93	1.28 (n.s.)	3
Chemical Manuf.	6	2.77	123	0.96 (n.s.)	3

Table 4. Massachusetts Occupations at Increased Risk for Mesothelioma and/or Lung Cancer

	Mesothelioma		Lung Cancer		Asbestosis
Occupation	# of Cases	SMOR	# of Cases	SMOR	# of Cases
Construction trades	44	3.63	870	1.35 (whites)	54
			30	2.68 (blacks)	
			24	2.86 ("other" races)	
Plumbers, pipefitters	12	8.86	105	1.42	18
Carpenters	9	3.12	220	1.38	11
Electricians	6	3.13	97	0.94 (n.s.)	5
Construction laborers	9	4.20	207	1.78	6
Engineers	10	2.45	165	0.68 (n.s.)	1
Other laborers	8	2.15	319	1.47	5
Janitors	7	1.35 (n.s.)	416	1.48	4
Mechanics	7	1.55 (n.s.)	344	1.36	4
Painters	1	--	165	1.79	5
Machinists	4	--	235	1.43	11
Sheetmetal workers	2	--	53	2.35	3
Textile machine operators	5	2.13 (n.s.)	204	1.23	3
Welders	4	--	88	2.84	3

n.s. - not statistically significant
-- SMOR not calculated due to small numbers

CONCLUSIONS

The findings of this study are a tragic reminder. Taken together with previous study results, they suggest that workers in a number of Massachusetts industries where asbestos was used, most notably shipbuilding and construction, have incurred substantial health risks as a result of their employment. Many have died or are currently sick due to asbestos exposures. Other workers live with the anxiety of knowing they have been exposed and are at risk of fatal occupational disease. It is estimated that a minimum of 3,600 workers will develop asbestos-related lung diseases in Massachusetts between 1991 and 2010 (see Appendix A).

The experience of these workers, in part documented in this report, carries with it a public health imperative to prevent future asbestos-related disease by controlling exposures. While new uses of asbestos are being phased out, worker exposure to in-place asbestos must be addressed. Prevention efforts should include rigorous enforcement of existing state and federal asbestos regulations and increased education of high-risk workers about asbestos hazards. Information about asbestos and relevant regulations can be obtained by contacting the appropriate federal, state or local agency (see Appendix B).

The long-term health effects of low level asbestos exposures in buildings are unclear. It is, however, standard public health practice to act cautiously in the face of scientific uncertainty. Programs to evaluate and monitor potential asbestos in all pubic buildings should be encouraged. Occupants should be informed of potential risks and asbestos education programs should be developed for building maintenance workers.

The relatively high excess of lung cancer among minority construction workers in this study is disturbing in light of mounting evidence that people of color are disproportionately concentrated in high risk jobs. There is anecdotal evidence that many of the asbestos removal workers in Massachusetts are also people of color. This underscores the need for linguistically and culturally appropriate education programs. Research should also be carried out to gain insight into the factors which place minority workers at high risk of developing occupational diseases.

Ongoing surveillance of asbestos-related lung diseases is necessary to evaluate the potential health effects of low level exposures, differences in risks by race, and the effectiveness of asbestos control efforts. The Department of Public Health will continue to use cancer registry and death certificate data to monitor asbestos-related lung diseases among Massachusetts workers.

The final act of the asbestos tragedy would be our failure to learn from this experience. Substances should be adequately tested for health effects before introduction into the workplace and the marketplace. Uses of toxic materials should be reduced by substitution with safer alternatives. Correspondingly, resources should be allocated to developing these alternatives. Toxic materials which are used should be rigorously controlled in the workplace and employees should be taught about work-related health risks and their legal rights to healthful and safe work environments.

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APPENDIX A

Projected Number of Cases of Asbestos-Related Lung Disease in Massachusetts from 1991 to 2010

Time Period	Mesothelioma # cases/year	Lung Cancer: Mesothelioma case ratio	Lung Cancer # cases/year	Asbestosis # cases/year	Total # of cases/ period
1991-1995	50	3	150	25	1125
1996-2000	46	3	138	20	1020
2001-2005	42	2	84	20	730
2006-2010	42	2	84	20	730
Total					3605

We have applied the basic methodology from several studies to make a rough estimate of the expected number of cases of asbestos-related lung disease in Massachusetts for the years 1991 through 2010. We started with the average number of cases of mesothelioma reported to the Massachusetts Cancer Registry for 1982-1987 and projected the numbers into the future based on studies of national projections. We assumed that 80% of all mesotheliomas are asbestos-related. Then we estimated the number of future lung cancer cases related to asbestos by multiplying the numbers for mesothelioma by a figure estimated from various studies to be the expected ratio of the two diseases. This multiplier figure has varied among different studies, but we used midrange estimate of three cases of asbestos-related lung cancer for every case of mesothelioma. This figure is expected to drop to approximately two at the beginning of the next century because the number of asbestos-related lung cancer cases is expected to begin decreasing before mesothelioma does due to mesothelioma's longer latency. We estimated the number of future asbestosis cases by using the state average of 25 deaths per year for 1982-1987 with asbestosis listed as the underlying or a contributing cause of death to project through 1995 and 20 deaths per year thereafter since cases of this disease are expected to decline. Since asbestosis is underreported on death certificates, these figures are low estimates of the true numbers of cases. Also, although case ascertainment of mesotheliomas are believed to be quite high, if more than 80% are asbestos-related the figures for mesothelioma and lung cancer would be higher. The total of 3,605 projected cases should therefore be considered a minimum estimate.

APPENDIX B

Federal, State and Local Asbestos Information Contacts

FEDERAL

Occupational Safety and Health Administration (OSHA) regulates worker protection standards and exposures	**(617) 565-7164 ext. 31**
Environmental Protection Agency (EPA) regulates asbestos in schools coordinates state-delegated National Emissions Standards for Hazardous Air Pollutants (NESHAPs) program	**(617) 565-3265**
Department of Transportation (DOT) regulates transportation of asbestos	**(617) 494-2770**
National Asbestos Hotline	**(800) 424-9065**

STATE

Department of Environmental Protection (DEP)

Division of Air Quality Control (DAQC) enforces NESHAPs standards requires notification and strict work practices for asbestos removal, storage, transportation and handling inspects demolition/renovation and manufacturing operations	**(617) 292-5630**
Division of Solid Waste (DSW) regulates storage, handling and landfilling of asbestos and asbestos-containing material	**(617) 292-5983**
Division of Hazardous Waste (DHW) regulates hazardous material clean-up: material must be reported if released to ambient air, friable asbestos is a hazardous material if not properly contained	**(617) 292-5851**
Office of Right-to-Know (RTK) regulates employers' filing of Material Safety Data Sheets for asbestos in the workplace	**(617) 292-5810**

APPENDIX B (continued)

Federal, State and Local Asbestos Information Contacts

STATE

Department of Labor and Industries (DLI)
regulates worker protection in state, county and municipal government buildings

Division of Occupational Hygiene (DOH) **(617) 969-7177**
surveys state, county and municipal buildings for asbestos
performs surveys to estimate asbestos exposure risk to employees
provides general information regarding asbestos

Division of Industrial Safety (DIS) **(617) 727-1933**
enforces DLI worker protection regulations
licenses and certifies asbestos abatement contractors, workers and consultants

Department of Public Health (DPH) **(617) 727-2660**
regulates residential asbestos repair or removal which must be done in accordance with the State Sanitary Code: requires plans to be submitted by owner to Local Boards of Health for approval

Executive Office of Administration and Finance

Division of Capital Planning & Operations (DCPO)
has contract standards for asbestos removal and repair in state-owned buildings **(617) 727-4123**
certifies asbestos contractors for state and local building work **(617) 727-9320**

LOCAL

Local Boards of Health
regulate residential asbestos conditions, outdoor dust pollution, indoor air conditions, and approve disposal of asbestos in local landfills

HEPATITIS B IN MASSACHUSETTS HEALTH CARE WORKERS

1984-1989

Occupational Health Surveillance Program
Bureau of Health Statistics, Research and Evaluation
Massachusetts Department of Public Health

December 1990

ACKNOWLEDGEMENTS

This report was prepared by Ben Kligler, M.D. and Letitia Davis, Sc.D. of the Occupational Health Surveillance Program in the Bureau of Health Statistics, Research and Evaluation. The authors would like to thank Al DeMaria, Paul Etkind, Susan Lett and Sally Cheney of the Bureau of Communicable Disease Control for their cooperation and advice.

The research upon which this report is based was supported in part by funds provided by the National Institute for Occupational Safety and Health.

SUMMARY

Hepatitis B has long been recognized as a major occupational health hazard for health care workers due to their frequent exposure to blood and other infectious body fluids. The federal Occupational Safety and Health Administration (OSHA) is currently in the process of developing a standard governing occupational exposure to bloodborne infections including hepatitis B. While the need for universal precautions in handling body fluids has been widely accepted, the question of who should receive hepatitis B vaccine is still controversial.

This report summarizes hepatitis B cases among health care workers reported to the Massachusetts Department of Public Health during 1984-1989. It includes information about which categories of workers and what types of health care facilities are apparently most affected. Although the findings are limited due to incomplete reporting of hepatitis B cases, they do indicate that service as well as direct patient care employees are at risk. Also, a substantial proportion of reported cases occurred among employees of non-hospital facilities including nursing homes, dentists offices and mental health facilities. These findings, together with those of previous studies, underscore the need to extend prevention programs to service as well as direct patient care employees and to other types of facilities as well as hospitals.

INTRODUCTION

This report was compiled by the Occupational Health Surveillance Program of the Bureau of Health Statistics, Research and Evaluation, Massachusetts Department of Public Health (MDPH). Its purpose is to make available to other parts of MDPH, to health care providers, to unions, and to the public, data collected by the MDPH's Bureau of Communicable Disease Control regarding the extent of hepatitis B in health care workers in Massachusetts over the past six years. It includes information regarding which categories of workers and what types of health care facilities are apparently most affected.

The need for universal precautions in the handling of body fluids in health care has been widely accepted. The question of who should receive the hepatitis B vaccine, however, is still the focus of controversy. Information about which groups of workers are at risk is necessary to develop adequate hepatitis B vaccination policies.

BACKGROUND

A. Health Effects

Hepatitis B is a viral illness transmitted sexually, perinatally, and through contact with blood or other infectious body fluids. It is a serious problem for several reasons. First, it can cause significant morbidity, resulting in hospitalization in 5-10% of symptomatic cases;[1] illness can last from a few weeks to several months. Second, acute infection with hepatitis B virus (HBV) can result in death: 1-2% of reported cases will develop fulminant hepatitis, and 85% of these will die.[2] Third, though most cases of hepatitis recover and have no lasting sequelae, some 5-10% of infected adults will go on to develop the carrier state. This means that not only are they continually infectious, but they are vulnerable to the long-term complications of hepatitis, which include cirrhosis of the liver, chronic active hepatitis, and primary hepatocellular carcinoma, any of which can be fatal. Female carriers who become pregnant can also transmit the virus to their offspring, exposing them to the risk of long-term sequelae.

Hepatitis B has long been recognized as a major occupational hazard for health care workers, due to their frequent exposure to blood and other infectious body fluids. The Centers for Disease Control (CDC) estimates that approximately 18,000 health care workers become infected with HBV each year in the U.S., resulting in 500-600 hospitalizations and over 200 deaths. Approximately 1,000 health care workers become HBV carriers each year, exposed to the long term risks outlined above.[2] Seroprevalence surveys show that 15-30% of health care workers with frequent blood contact have serological evidence of HBV infection, compared to only 3-5% of the general population; prevalence of the carrier state in this group of workers is 1-2%, compared to 0.3% in the general population.[3]

B. Current Regulations Regarding Hepatitis B Vaccination

Hepatitis B vaccine is approximately 90% effective in preventing transmission of the disease. It costs over $90 per series.[3] An Occupational Safety and Health Administration (OSHA) compliance directive currently in effect requires health care facilities to provide hepatitis B vaccine, free of charge, to any employee "with substantial exposure to blood or blood products." Final OSHA regulations governing protection of employees from occupational exposure to bloodborne infections are now in the last phases of development, and will probably be released in early 1991. The most recent draft of these regulations requires provision of the vaccine to any worker who has contact with blood at least once per month. The definition of who should be provided with the vaccine has been controversial, as the unions believe that the once-or-more-a-month standard is arbitrary and that all workers with any degree of exposure should have access to the vaccine. OSHA is reportedly considering a task-based risk classification standard rather than one based either on frequency of exposure or job title.

Because the public sector is outside of OSHA jurisdiction, whatever standards OSHA ultimately adopts will not apply to employees of public health care facilities in states such as

Massachusetts which do not have state OSHA plans.* However, OSHA regulations will likely be viewed as the standard of care for the entire health care industry and thereby affect public sector institutions.

C. Current Vaccination Practices

A survey of 329 hospitals and 318 nursing homes conducted by OSHA in 1990[4] revealed several important facts regarding current use of the hepatitis B vaccine. Only 46% of direct patient care and laboratory workers in hospitals have been vaccinated against hepatitis B; among service workers in hospitals, the figure is only 31%. In nursing homes, only 12% of the patient care workers, and 2% of the housekeeping staff, have received the vaccine. Only 58% of hospitals offer the vaccine free to all patient care and laboratory workers; an additional 26% offer the vaccine free to "high risk" employees, but this is defined in a wide variety of ways. In nursing homes, only 1% of direct patient care employees exposed to blood at least once per month are offered the vaccine free of charge; of housekeeping employees in the same exposure category, 0.4% are offered the vaccine free of charge.

Finally, the survey revealed that even where the vaccine is offered there are problems with its acceptance by employees. Of direct patient care and laboratory workers in hospitals offered the vaccine free of charge, only 53% have accepted. Similarly, only 61% of hospital housekeeping workers offered the vaccine have chosen to accept it. This problem with acceptance is thought to stem from two sources: 1) lack of knowledge among employees regarding the severity of hepatitis B and its possible consequences; and 2) lingering fears regarding the safety of the hepatitis B vaccine. The first vaccine developed against hepatitis B in the early 1980s was plasma-derived, produced from the blood of people who had hepatitis B. The nature of this vaccine raised fears in potential recipients about transmission of AIDS.

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* In states which have elected to enforce the OSHA law under "State OSHA plans" federal health and safety protections are extended to cover state, county and municipal employees. Currently, Massachusetts does not have a state OSHA plan, thus these public employees will not be covered under the new OSHA standard governing occupational exposure to blood-borne pathogens.

Although it was shown in 1984 that no cases of transmission of AIDS were ever associated with this vaccine,[5] and although there is no subsequent evidence of such transmission, these unfounded fears have led many to refuse vaccination. Since that time, a new vaccine produced through recombinant DNA techniques and not derived from human plasma has been developed. Many health care workers are unaware that this recombinant vaccine is now the one most widely used, and so continue to have fears regarding the safety of the vaccine. This low acceptance rate points to the need to educate health care workers regarding both the severity of hepatitis B and the safety of the new vaccine as part of any vaccination program.

D. Vaccination Policies and Practices in Massachusetts

In 1987, the Immunization Program of the MDPH conducted a survey of immunization policies in Massachusetts hospitals. Of the 157 facilities responding, approximately 80% of general hospitals and 50-60% of chronic care and psychiatric hospitals were providing hepatitis B vaccine free of charge to employees.[6] Overall, Massachusetts practices at that time appeared to be similar to practices in the country as a whole, with only 65% of hospitals responding providing free vaccine to employees. At that time, MDPH recommended active immunization of "persons felt to be at substantial risk of HBV infection who are demonstrated or judged likely to be susceptible...Health care personnel who have frequent contact with blood or blood products ...including (but not limited to) physicians, nursing staff, dental professionals, and laboratory technicians."[6] These recommendations did not address the question of whether employer or employee should bear the cost of the vaccine.

METHODS

Hepatitis B is reportable by law to local health departments in Massachusetts. When a provider reports a case, the local health department is then responsible for interviewing the case and completing the CDC Viral Hepatitis Case Report, which includes demographic data,

clinical information, and information regarding the case's risk factors for hepatitis B. Risk factors specified on the form include IV drug use, homosexual activity, transfusion, contact with a confirmed or suspected hepatitis B case, work in a medical or dental field, hospitalization, treatment by a dentist, association with a dialysis unit, and other percutaneous exposure (see copy of report form, Appendix A). Two copies of this form are then forwarded to the Bureau of Communicable Disease Control, within MDPH.

Until mid-1985, MDPH field epidemiologists were available to actively follow up case reports in conjunction with the local boards of health. Since that time, there have been no epidemiologists with this responsibility, and surveillance at the state level has been entirely of the passive type. In this passive surveillance system, MDPH receives reports from local boards of health but does not actively gather information in the field; such systems are in general more vulnerable to changes in reporting practices at the local level than are active surveillance systems. Based on reporting practices for other communicable diseases in Massachusetts, and on estimates of the effectiveness of passive surveillance of hepatitis in other states,[7] it is estimated that approximately 10-20% of hepatitis B cases occurring in the state are actually being reported to the MDPH. Of those that are reported, approximately 70% have risk factor information documented on the report form.

All hepatitis B case reports received by the MDPH for the years 1984 to 1989 were reviewed. Though the category of health care work is not specified on the report form, many of the case reports include additional information regarding either job category, type of facility, or both. For those cases reported as "employed in a medical or dental field," information regarding all risk factors, type of health care work and type of facility was abstracted and summarized. For the purposes of this analysis, IV drug use, homosexual activity, transfusion, contact with a confirmed or suspected hepatitis B case, and work in a medical or dental field were defined as major risk factors. Hospitalization, treatment by a dentist, association with a dialysis unit and other percutaneous exposure were defined as minor

risk factors. Data on the total number of cases reported in each year were received from the Bureau of Communicable Disease Control; this figure was not available for 1984.

RESULTS

A total of 4,439 cases of hepatitis B were reported to the MDPH for the years 1984-1989 (this does not include 1984, for which summary totals were not available). Of these 4,439 cases, 205 were among health care workers. Of the cases that did have health care worker recorded as a risk factor, approximately 20% had another major risk factor--IV drug abuse, homosexual contact, sexual contact with a known hepatitis B case or carrier, or history of blood transfusion--as well. All cases in health care workers with any of the four major risk factors listed above were omitted from this analysis, since it was too difficult to clearly attribute their case to occupational exposure. This left a total of 163 health care worker cases for the years 1984-1989. Health care worker cases with additional minor risk factors were retained in the analysis.

The number of reported cases having health care worker as their only major risk factor ranged from 10 to 46 per year during the study period. Assuming that 10-20% of all hepatitis B cases were being reported, and since only 70% of these were being reported with risk factor information, these figures would comprise only 7-14% of the actual incidence of hepatitis B in health care workers. Given the above reporting limitations, then, these 10-46 cases per year probably reflect a true incidence among health care workers in Massachusetts ranging from 71 to 657 cases per year over the study period. It is not known if hepatitis B cases in health care workers are diagnosed or reported more frequently than those occurring in the general population. If such a reporting bias does exist, it could cause us to overestimate the true incidence.

The distributions of health care worker cases by job category and type of facility are shown in Tables 1 and 2. It should be remembered that due to the limitations in the data

imposed by gaps in reporting, the figures in these breakdowns may represent only 7-14% of the health care workers actually affected and that the true number of cases in each category may be much greater than the numbers presented. Furthermore, it is not known if the failure to report cases is related to job category or type of facility; if it were, this could bias results. Because of these limitations, the data are useful not so much for calculating estimates of incidence as for examining which categories of job type and facility type are at risk. Such information will help focus efforts at prevention.

The percentage of all cases with risk factor information comprised of health care workers with no other major risk factors is presented for each year in Table 3. This table shows that both the overall number of cases reported among health care workers and the percentage of all reported Massachusetts cases represented by health care workers have dropped over the past five years.

DISCUSSION

The incompleteness of hepatitis B reporting and the possible biases introduced by reporting practices make it difficult to draw definite conclusions from these data regarding which categories of job or facility type are most affected. In spite of these cautions, though, a number of interesting facts do become evident on examining the data.

The breakdown by job category in Table 1 shows that although the largest percentage of cases occurs in nurses and nurse's aides (30.7%), a substantial number also occur in laundry, housekeeping, maintenance and dietary workers (14.1%). Though we cannot use these data to estimate incidence in each category due to incomplete and possibly biased reporting, the results are consistent with previous studies of both incidence and prevalence, which have repeatedly shown nurses, nurse's aides, housekeeping, laundry, and food service workers to be among the groups most at risk for HBV infection.[8,9] These findings point to the need to focus prevention not just on direct patient care employees but on service employees as well.

The breakdown by type of facility in Table 2 shows, as we might expect, that the majority (31.9%) of cases occur in hospital employees. However, employees of nursing homes (14.7%), dentists' offices (8.0%), and mental health facilities (6.7%) constitute substantial proportions of the cases. The latter category is of special concern for occupational exposure due to the very high rate of hepatitis B carriage among clients of institutions for the mentally ill and mentally retarded. All of the non-hospital cases are of interest, given the very low percentage of non-hospital health care facilities currently offering the vaccine to employees free of charge.

The decline in both the number of cases in health care workers and the percentage of health care workers among all cases, seen in Table 3, is probably due to two factors. First, it is reasonable to assume that the practice of universal precautions in the handling of body fluids, combined with the delivery of hepatitis B vaccine to some health care workers, has had an impact on incidence. Such a decrease would be consistent with national trends among health care workers, where incidence has fallen significantly in recent years. A recent CDC report found that in the four active surveillance "sentinel counties" for hepatitis, the percentage of all reported cases comprised of health care workers declined from 3.1% in 1982 to 1.1% in 1988.[10] Second is the fact that there has been a decline in the total number of cases reported in each year as well as in the number of health care worker cases reported, probably reflecting a change in reporting practices. Though there is some evidence from national CDC data that incidence of hepatitis B has declined slightly since 1985,[3] the 57% decline in cases reported in Massachusetts since 1985 is too large to be explained solely by this modest drop in national rates. The loss of the field epidemiologists responsible for active follow-up of hepatitis B cases probably explains at least some part of this decline.

The percentage of the decline explained by each of these two factors--preventive measures and change in reporting practices--is impossible to determine. It is encouraging, though, to see the percentage of cases among health care workers declining in Massachusetts

Table 1. Hepatitis B in Massachusetts Health Care Workers by Job Category, 1984-1989.[1]

Job Category	1984	1985	1986	1987	1988	1989	Total (%)
RN/LPN	8	5	6	7	5	2	33 (20.2)
Nurse's aide	5	3	7		2		17 (10.4)
Laundry/ Housekeeping	4	5		2	1	1	13 (8.0)
Dentist	3	2	3		1		9 (5.5)
Lab tech/ Phlebotomist	1	4	1	1	2		9 (5.5)
Maintenance	1	4			1		6 (3.7)
Physician	2	2	1				5 (3.1)
MH/MR Worker	1	1	1	1			4 (2.5)
Home health aide		1	1	1		1	4 (2.5)
Dental hygienist	1	1		1	1		4 (2.5)
Dietary		2		1		1	4 (2.5)
EMT/Paramedic	1			2			3 (1.8)
Secretarial		2					2 (1.2)
Transport	1			1			2 (1.2)
Sterilizing tech		1					1 (0.6)
Undertaker's assistant		1					1 (0.6)
Medical supply		1					1 (0.6)
Unknown	13	11	10	2	4	5	45 (27.6)
Total	**41**	**46**	**30**	**19**	**17**	**10**	**163 (100)**

[1]Cases with other major risk factors are excluded.

as well as nationally, since this implies that prevention methods can be effective and that additional reductions could be achieved with more intensive efforts.

Table 2. **Hepatitis B in Massachusetts Health Care Workers by Type of Facility, 1984-1989.**[1]

Type of Facility	1984	1985	1986	1987	1988	1989	Total (%)
Hospital	13	19	5	6	4	5	52 (31.9)
Nursing home	4	5	7	2	3	3	24 (14.7)
Dentist's office	4	3	3	1	2		13 (8.0)
Mental health facility	3	2	4	1	1		11 (6.7)
Home/Private duty		2	1	2		1	6 (3.7)
EMS	1			2			3 (1.8)
Laboratory				1	1		2 (1.2)
Physician's office			1				1 (0.6)
Rehab day program			1				1 (0.6)
Chair van company				1			1 (0.6)
Funeral parlor		1					1 (0.6)
Medical supply company		1					1 (0.6)
Unknown	16	13	8	3	6	1	47 (28.8)
Total	**41**	**46**	**30**	**19**	**17**	**10**	**163 (100)**

[1]Cases with other major risk factors are excluded.

Table 3. Massachusetts Health Care Worker Cases as a Percentage of Total Massachusetts Cases with Risk Factors Reported, 1984-1989.[1]

	1984	1985	1986	1987	1988	1989
Health Care Worker cases reported	41	46	30	19	17	10
Total cases reported	N/A	1266	1035	927	648	553
Total cases reported with risk factor information[2]	N/A	886	725	649	454	387
Percentage[3]	N/A	5.2%	4.1%	2.9%	3.7%	2.6%

[1]Cases with other major risk factors are excluded.

[2]Computed as (Total reported cases)(.7), where .7 represents the approximately 70% of cases containing risk factor information on the report form.

[3]Computed as (Health care worker cases reported)/(Total cases reported with risk factor information).

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Surveillance of Occupational Asthma Under the SENSOR Model*

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NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration; RAST = radioallergosorben test; SENSOR = Sentinel Event Notification System for Occupational Risks; SHE(O) = Sentinel health event (occupational)

Much of this workshop is devoted to reviewing current scientific knowledge concerning the causation, diagnosis, and natural history of occupational asthma. Provided with this information, primary care physicians should be able to enhance their role in the prevention and optimal management of this condition. In addition to knowledgeable practitioners, however, certain nonclinical services and expertise are often needed to assess and control occupational asthma in a particular workplace after an index case is recognized. To effectively bring our prevention "know-how" to bear on occupational asthma, surveillance programs are needed that link practitioners who recognize occupational asthma cases to resources in industrial hygiene, epidemiology, and occupational medicine.

The National Institute for Occupational Safety and Health and others have recognized that occupational disease surveillance is presently inadequate in the country.[1] Recently, NIOSH initiated a pilot project with 10 state health departments known as the Sentinel Event Notification System for Occupational Risks, or SENSOR,[2] to improve the surveillance of occupational asthma as well as other work-related conditions. In this report we discuss public health surveillance in general, describe the SENSOR model, discuss occupational asthma as a target condition for SENSOR, and describe the implementation of SENSOR and the early experience in selected states conducting occupational asthma surveillance using this model.

Surveillance and Disease Prevention

Public health surveillance has been described as "the collection, collation, and analysis of [health] data and the dissemination to those who need to know so that action [to prevent and/or control disease] can result."[3] According to this definition, surveillance should be distinguished from research into causes. Indeed, most public health surveillance protocols focus on conditions for which important causes (and preventive measures) have already been identified. As with most occupational diseases, prevention of occupational asthma requires multiple intervention strategies and multiple approaches to surveillance. To see how SENSOR fits into an overall approach to occupational asthma surveillance, we will first consider different types of surveillance systems and how they relate to disease prevention.

Some surveillance systems focus on detection of individual cases of a health event or of individuals with risk factors for the health event so that preventive actions can be directed at the patient and, where appropriate, at contacts of the patient. An example would be a program for identifying individuals with tuberculosis to ensure that patients were appropriately treated and contacts received appropriate chemoprophylaxis. In other surveillance systems, the principal objective is to monitor trends or patterns of a health event or of risk factors. Trend monitoring may be used to target high-risk populations for intervention efforts or to monitor the efficacy of interventions. An example would be monitoring the number of deaths from pneumonia and influenza in selected US cities to identify and assess the impact of national and regional influenza outbreaks.[4] Of course, a single surveillance program may serve both case identification and trend monitoring functions. SENSOR is intended primarily to serve a case detection function.

For a given health condition, prevention and surveillance can be directed toward multiple points along the path from exposure to the development of clinical disease. In the case of occupational asthma (Fig 1), prevention would ideally focus on preventing exposure to known sensitizing agents. Since these primary prevention measures will not always be feasible or universally implemented, medical screening can be conducted to detect early sensitization (or risk factors for sensitization) and limit further exposure in the sensitized individual. When primary and secondary prevention measures are not completely effective or implemented, clinical occupational asthma will occur. In order to target and monitor preventive measures, surveillance systems can monitor chemical use and exposure, early disease markers, and clinical occupational asthma, the occurrence of which may indicate a need to improve prevention and surveillance earlier in the chain of causation. SENSOR focuses on the end point of clinically diagnosed occupational asthma and should be viewed as one facet of a comprehensive approach to surveillance.

A surveillance system may also be classified according to the type of data it uses. Surveillance data may be collected specifically for surveillance, or existing secondary data (data originally collected for purposes other than surveillance) may be used. Examples of existing data sources that have been used for surveillance include death certificates, hospital discharge summaries, and workers' compensation claims. Although use of such documents has the advantage of not requiring additional resources for data collection,

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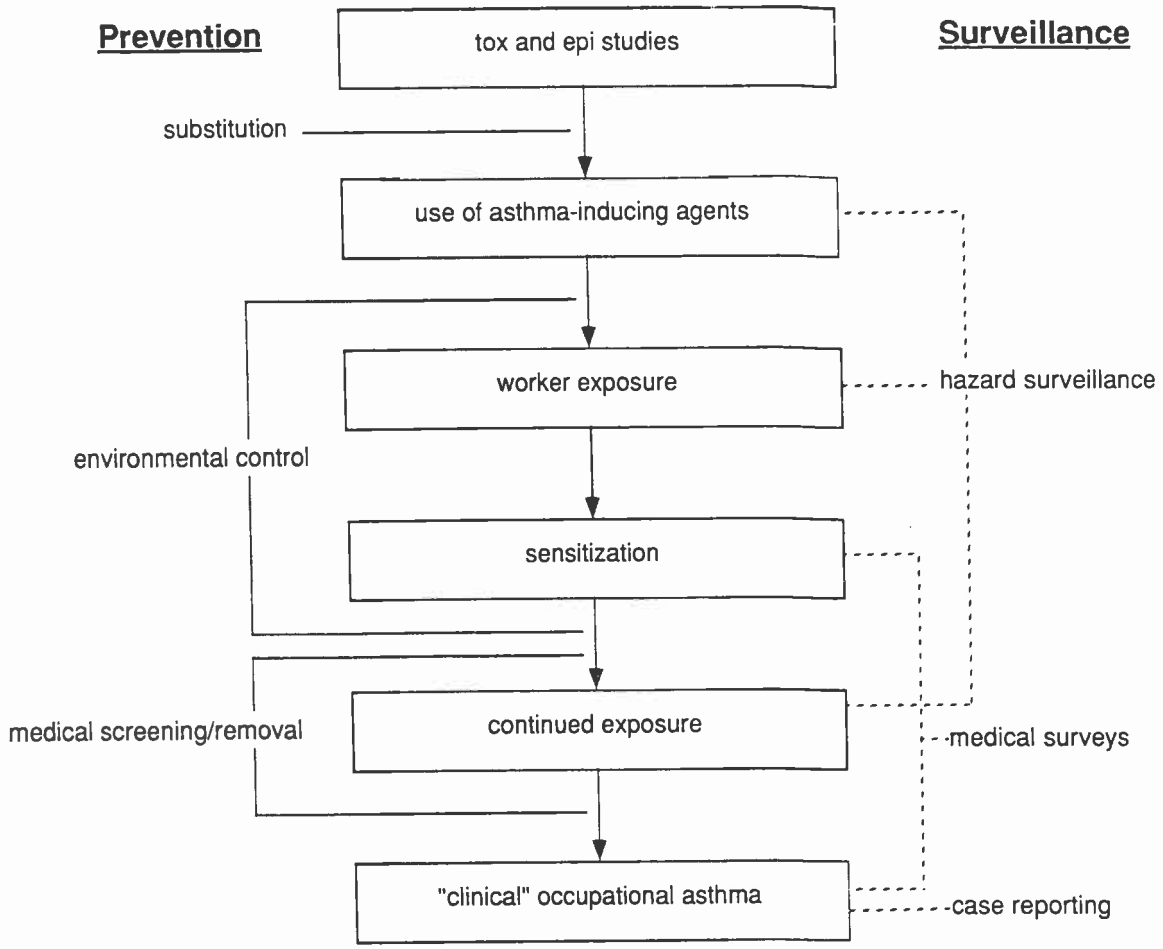

FIGURE 1. Prevention and surveillance of occupational asthma.

these data sources only identify cases resulting in death, hospitalization, or compensation and may be inadequate for surveillance of certain conditions. The SENSOR model, which proposes the use of health care provider reports, is aimed at conditions for which other sources of surveillance data are inadequate for timely case detection.

In addition to detecting conditions not identified by existing data sources, physician reports may have other advantages. First, physician reports are generally available in a more timely way than, for example, hospital discharge data or workers' compensation claims data. Timeliness is especially important when case reports are used to direct intervention efforts in individual cases or during outbreaks. Second, for conditions such as toxic shock syndrome, where the diagnosis may not be straightforward, physician reporting may allow interaction between the surveillance program and physician, collection of clinical data needed for case confirmation, and suggestions for additional clinical evaluation when appropriate. Finally, by establishing a contact point for physicians to report specified diseases, physician reporting systems can also provide physicians with a resource for reporting unusual cases or clusters that may be of public health concern but are not legally notifiable.

The idea of using health care provider reports to identify cases of occupational disease is not new. According to a survey conducted in 1985,[5] 32 states had programs for reporting occupational illnesses by one or more sources, including physicians (25 states), hospitals, laboratories, and others. In 16 states, legal penalties existed for nonreporting. Such programs are hampered by severe underreporting by physicians,[6] for several reasons. Many programs require reporting of any and all occupational diseases without further guidance as to what conditions are reportable or what criteria should be used for reporting occupational diseases.[7] Many practitioners lack the training needed to recognize work-related conditions.[6,8] Others may perceive occupational disease reporting as having little utility, perhaps because of a lack of intervention programs linked to reporting, as well as a focus on individual patient care and a lack of orientation to public health among clinicians. Finally, some practitioners may be unwilling to report because they provide services to employers or because they are reluctant to become involved in workers' compensation systems.

THE SENSOR PROGRAM

The SENSOR model for occupational disease surveillance is intended to address some of the deficiencies enumerated above in previous occupational disease reporting programs. Conceptually, SENSOR has 4 principal components: a set of selected target conditions, a network of sentinel health care providers, a surveillance center that receives and analyzes reports, and worksite intervention activity that is guided by surveillance data.

SENSOR targets for reporting a selected sentinel health

event (occupational) [SHE(O)]. A SHE(O) is a preventable work-related disease, death, or disability[9] that serves as a signal that other workers in the same workplace, industry, or occupation may be at risk of a similar outcome and may benefit from interventions to abate a hazard or to detect and treat early disease. Although a single SHE(O) will not always provide enough information to implement a specific intervention, it may indicate that targeted industrial hygiene or epidemiologic studies are needed. SENSOR is a model for using health care provider reports to identify and respond to individual occupational disease cases.

The second component of the SENSOR model is a network of sentinel providers, such as physicians, clinics, nurse practitioners, or laboratories, likely to encounter the condition of interest by reason of their specialty, their practice setting, or some other consideration. The purpose of identifying sentinel providers is to target efficiently efforts to educate providers about the purpose of reporting and how to report a case. Dissemination of surveillance data can also be focused on the sentinel providers, alerting them to industries, occupations, and workplaces where occupational disease is being recognized in their State.

The third element of SENSOR is a surveillance center, usually located in the state health department. Its function is to analyze case reports, direct investigations and prevention activities at selected workplaces, and disseminate surveillance data to practitioners and others. Intervention, the fourth key component of SENSOR, may be carried out by staff in the surveillance center or referred to other agencies. Depending on the circumstances, workplace interventions may involve walk-through inspections, distribution of educational materials to employees, industrial hygiene surveys, questionnaire surveys, and screening of co-workers.

Occupational Asthma as a SENSOR Target Condition

SENSOR targets for reporting only those SHE(O)s most suited to provider reporting and intervention. These include conditions that have some or all of the following attributes: the condition is reasonably frequent, practitioners can attribute individual cases to work exposure with a reasonable degree of confidence, the induction period (between first exposure and disease recognition) is relatively short, individual patients can benefit from abatement of exposure, existing technology can be used to prevent new cases, and data sources are not available or are inadequate for surveillance purposes. Features of occupational asthma that make it suitable for SENSOR-type case surveillance are discussed below.

Occupational asthma is often a sentinel event because the prevalence of asthma can be high in industries where occupational asthma has been identified.[10] Individual cases may therefore identify large numbers of other at-risk individuals. Identification of new causes of occupational asthma—himic anhydride, for example[11]—can also follow the recognition of 1 or 2 cases. Other instances have been reported in which a known asthma-causing agent, such as toluene diisocyanate,[12] was not known to be present in a workplace until individual cases were recognized and investigated further. Investigations reported in the literature represent those situations when, by chance, a case is recognized at a center with the interest and capability to conduct work site investigations. By targeting asthma, a SENSOR program can provide a systematic mechanism for linking large numbers of practitioners to the resources for conducting work site investigations.

Although the incidence of occupational asthma in the United States is unknown, it is probably fairly common. Estimates of the proportion of asthma attributable to work range from 2% of adult asthma cases to 15% of asthma in Japanese males.[13] As an estimated 5 million adults in the United States have asthma,[14] the more conservative estimate of work attributability yields an estimated 100,000 prevalent cases of occupational asthma in the United States.

Provider reporting of all asthma cases would not be efficient or practical. For provider-based surveillance of occupational asthma to work, physicians must be able to recognize individual asthma cases that may be work-related. A survey of physicians in New Jersey suggests that diagnosis of occupational asthma by physicians is not unusual. Questionnaires were administered to 847 physicians who had discharged a patient with an occupational lung disease between 1985 and 1987. Of the 762 physicians (90%) who responded to the survey, 134 had seen at least one newly diagnosed case of occupational asthma in 1987; a total of 446 patients were seen during that year. Only 101 of these had been hospitalized, indicating that hospital discharge data would probably be an insensitive source of data for this condition (Rosenman K, Stanbury M, unpublished data).

It is likely that criteria for the diagnosis of occupational asthma vary among physicians and even among patients seen by the same practitioner. For surveillance purposes, it would be desirable to use consistent criteria for classifying cases as possibly work-related. To this end, NIOSH has developed a surveillance case definition for use by state health departments to classify cases reported by physicians in a consistent way (see Appendix). A definitive diagnosis of occupational asthma is not always straightforward, and the NIOSH definition is intended to identify individual patients with sufficient evidence of work-related asthma to warrant additional investigation. The definition is also intended to promote consistent counting of reported occupational asthma cases over time and by different states. The current definition was reached in an iterative fashion, based on comments from clinicians familiar with occupational asthma and feedback from state health departments after field testing of earlier versions. Like any definition used in surveillance, the definition of occupational asthma represents a compromise among specificity, sensitivity, and practicality, and it may not be appropriate for other uses.

The interval between first exposure to a sensitizing agent at work and the development of occupational asthma is variable, generally ranging from months to years.[15] Even for cases with a relatively long induction period, however, the sensitizing agent usually is still present in the workplace when symptoms arise (although the patient may have left the workplace). Thus, recognition of a case of occupational asthma may provide the opportunity for primary prevention in co-workers of the index patient.

Although some individuals remain symptomatic after abatement of exposure to certain asthma-causing agents,[10] a substantial proportion of those removed from exposure do recover, and others improve. Persons who remain in exposure

Table 1—*States Participating in SENSOR Program, 1989*

Colorado*	New York*
California	Ohio
Massachusetts*	Oregon
Michigan*	Texas
New Jersey*	Wisconsin*

*Occupational asthma is a target condition.

are more likely to have deteriorating health. Clearly, intervention to reduce or eliminate exposure to an asthmagen can benefit individuals already affected. Reporting and follow-up may therefore benefit index patients as well as coworkers with secondary occupational asthma identified in the course of a workplace investigation.

Implementation and Early Experience of Three State SENSOR Projects Conducting Occupational Asthma Surveillance

Of the 10 states participating in the SENSOR program, 6 identified occupational asthma as a target condition (Table 1). Three states, Massachusetts, Wisconsin, and New York, initiated their reporting activity with a small, selected group of practitioners with whom they interact on a regular basis. This approach was used to take advantage of particular circumstances in these states, such as the existence of state-supported occupational medicine clinics, and to gain experience with case reporting, follow-up, and workplace investigations. Three other states, Colorado, Michigan, and New Jersey, established more traditional reporting systems, soliciting reports from providers throughout each state. The experience of this latter group may be more generalizable and is the focus of the rest of this report.

All 3 programs have utilized the concept of sentinel providers by aiming publicity and outreach to physicians most likely to see patients with occupational asthma. Mailings and presentations have been addressed to pulmonary physicians, allergists, and occupational medicine specialists. In addition, all 3 state programs have used 1 or more additional data sources to identify groups of physicians who have diagnosed occupational disease or shown an interest in occupational exposures. These other groups include attending physicians identified from hospital discharge records with occupational lung disease diagnoses, physicians supplying health services to hazardous waste contractors, physicians identified by workers' compensation claims for respiratory disease, members of departments of family medicine and internal medicine at medical schools, and physicians previously reporting an occupational disease to the state under other reporting programs.

All 3 states have designed their reporting systems to minimize the effort needed to report a case. All allow physicians to report a suspected case by phone. Phone numbers for reporting are disseminated in letters to sentinel physicians, in state health department newsletters, at presentations to professional organizations, and in program brochures. After receiving a phone report, SENSOR staff personnel contact the physician reporting the case to request additional information and, if appropriate, to obtain medical records. Patients may also be contacted by phone to obtain additional history and information about the workplace. From this information, it is determined whether the patient's symptoms are consistent with occupational asthma, how many other workers may have had similar exposure, and if any other workers are symptomatic. All of this information is used to set priorities for workplace follow-up.

Each program has also encouraged reporting by marketing SENSOR, in part, as a service to physicians and patients. In addition to the workplace investigation service, other inducements, such as providing peak flow meters and RAST testing, have been offered to reporting providers.

Disease reporting may be either voluntary or mandatory (governed by state statutes or regulations). Important features of some reporting regulations are provisions for protecting the confidentiality of case report data and authorizing providers to release otherwise confidential medical data to state health officials. Penalties for nonreporting are probably the least important feature of such regulations, and they have rarely been enforced. In Michigan, an occupational disease-reporting law was already in effect when the SENSOR program started. With the implementation of SENSOR, physician education efforts and case follow-up were enhanced and focused on a few target conditions, including occupational asthma. In Colorado, voluntary occupational asthma case reporting started in October 1987, and in August 1988, state health regulations were modified to make occupational asthma a reportable condition. New Jersey implemented voluntary reporting of occupational asthma in 1988, but a mandatory reporting regulation is presently under consideration.

All 3 state programs have augmented existing expertise in areas relevant to occupational asthma surveillance. Each established a relationship with an academic occupational medicine program to obtain assistance in interpretation of individual case reports as well as in the design and conduct of workplace investigations. Colorado SENSOR works with the Occupational Health Program at the National Jewish Center for Immunology and Respiratory Medicine, Michigan SENSOR with the Department of Medicine at the College of Human Medicine, Michigan State University, and New Jersey SENSOR with the Occupational Medicine Division at the University of Medicine and Dentistry of New Jersey. In addition, each program has established or supplemented industrial hygiene capability. In Colorado and New Jersey, a full-time industrial hygienist is employed by the SENSOR program to participate in workplace investigations. The Michigan SENSOR program is within the states OSHA program, which is located in the state health department, and OSHA industrial hygienists, either in the compliance or consultation programs, participate in work site investigations triggered by case reports.

Sustaining a successful surveillance program requires dissemination of surveillance data, especially to those who have provided case reports. In each state, reporting physicians receive letters summarizing the results of work site investigations. These letters show providers how their reports have been used and in some cases provide information useful for case management. In addition, summaries of reported cases and noteworthy case investigations are disseminated in state health department newsletters, in state medical journals, at professional meetings, and at hospital grand rounds.

In the first year of reporting (June 1, 1988, to June 1,

Table 2—*New Jersey SENSOR Findings on First Eight Workplace Investigations*

Industry or Occupation	Agent(s)	Employees Exposed (*n*)	Employees Symptomatic (*n*)	Air Monitoring	Engineering Controls
Coffee processing	Green coffee beans	9	5	Ineffective	Ineffective
Renal dialysis	Formaldehyde	9	6	Ineffective	Ineffective
Renal dialysis	Glutaraldehyde	8	3	Ineffective	Ineffective
Yacht manufacturing	Isocyanate paints	15	2	Not in place	Ineffective
Yacht manufacturing	Isocyanate paints	20	2	Not in place	Effective
Realtor	Microbials	14	12	Not in place	Ineffective
Plastic foam products	Glue/adhesive (methyl ethyl ketone?)	3	2	Not in place	Ineffective
Food processing	Perlite	20	3	Not in place	Ineffective

1989), the New Jersey SENSOR program received 46 reports of possible occupational asthma cases. Data from the first 8 work site investigations are summarized in Table 2. As can be seen, these investigations identified other symptomatic individuals as well as work sites with inadequate engineering controls and air monitoring.

The Michigan SENSOR program added more intensive provider education and case follow-up activities to a preexisting mandatory occupational disease-reporting program. This resulted in a dramatic increase in the number of occupational asthma reports received, from a total of 18 during the period 1984-1986 to 101 reported between Sept 30, 1988, and Aug 3, 1989. Reported cases have come from a wide variety of exposure settings (Table 3), including cases that led to the recognition of a new setting for occupational asthma, sugar beet pulp processing. In 8 work site investigations that are completed or pending, employee interviews have identified 97 co-workers of employees reported to have symptoms suggestive of occupational asthma.

Between October 1987 and October 1989, Colorado SENSOR received 97 disease reports that fell in its occupational asthma category. Table 4 shows the workplace settings for which more than one case has been reported. Colorado's experience illustrates 1 of the benefits of a provider reporting system for specified conditions: it provides a contact point where physicians can report other conditions or clusters that they suspect are related to occupational or environmental exposure. For example, among the case reports received in Colorado is a cluster of 6 cases of probable hypersensitivity pneumonitis in swimming pool employees; this is currently being investigated.

Table 3—*Exposures and Settings for the First 30 Occupational Asthma Cases, Michigan SENSOR*

No of Cases	Exposure	Type of Workplace or Occupation
14	Isocyanates (TDI, MDI, NDI)	Auto parts manufacturer, florist, car dealers
4	Grain/plant dusts	Grain mill, sugar beet pulp mill
2	Cobalt	Carbide tools
2	Formaldehyde	Auto parts manufacturer, cabinet maker
2	X-ray developer	Medical, dental offices
2	Ventilation system	Office workers
2	Coolant	Transmission manufacturer
1	Epoxy	Aircraft part manufacturer
1	Chromium	Tool manufacturer

Conclusions

SENSOR is a system for linking physicians who recognize occupational disease cases to public health officials who can direct intervention at specific workplaces and alert other physicians to settings where occupational disease may be occurring in their state. Certain features of occupational asthma may make it suitable for surveillance under the SENSOR model. Experience from a limited number of states indicates that many physicians are willing to report occupational asthma cases to state health officials and that case reports can be used to identify workplaces with remediable health hazards.

From early experience, SENSOR shows promise as an approach to providing occupational asthma surveillance and identifying opportunities for primary and secondary prevention. More widespread and sustained application of the SENSOR method requires that certain issues be addressed. Confirmation and investigation of occupational asthma cases are labor-intensive and demand certain types of expertise. As with notifiable communicable diseases, underreporting is a persistent problem. To encourage reporting, sufficient resources must be devoted to assure timely, quality follow-up of patients and to demonstrate the utility of reporting to providers. Further efforts are needed to increase physician recognition of occupational disease. These efforts should include dissemination of reporting criteria, surveillance data, and other educational material to providers through the SENSOR surveillance system.

Table 4—*Exposure Settings for Selected Cases Reported to Colorado SENSOR*

No of Cases	Type of Workplace or Occupation
25	Office workers (14 in one building, 9 in one building)
6	Swimming pool employees
3	Diesel mechanics
3	Foam manufacture
3	Auto painter
3	Sales clerks
3	Teachers
2	Beauty salon
2	Waferboard manufacture
2	Custodian

Appendix

Surveillance Guidelines for State Health Departments:

OCCUPATIONAL ASTHMA

October 4, 1989

Reporting Guidelines

State health departments should encourage providers to report all suspected or diagnosed cases of occupational asthma. These should include individuals with:

(A) A physician diagnosis of asthma

and

(B) An association between symptoms of asthma and work

Surveillance Case Definition

State health departments should collect appropriate clinical, epidemiologic, and workplace information on reported cases as needed to set priorities for workplace investigations. The surveillance case definition includes meeting criteria A and B below.

(A) A physician diagnosis of asthma[a]

and

(B) An association between symptoms of asthma and work[b] plus any 1 of the following:

(1) Workplace exposure to an agent or process previously associated with occupational asthma[c]

or

(2) Significant work-related changes in forced expiratory volume in one second (FEV_1) or peak expiratory flow rate (PEFR)

or

(3) Significant work-related changes in airways responsiveness as measured by nonspecific inhalation challenge[d]

or

(4) Positive response to inhalation provocation testing with agent to which patient is exposed at work. Inhalation provocation testing with workplace substances is potentially dangerous and should be performed by experienced personnel in a hospital setting where resuscitation facilities are available and where frequent observations can be made over a sufficient time period to monitor for delayed reactions.

---

[a]"Asthma is a clinical syndrome characterized by increased responsiveness of the tracheobronchial tree to a variety of stimuli."[1] Symptoms of asthma include episodic wheezing, chest tightness, and dyspnea or recurrent attacks of "bronchitis" with cough, sputum production, and rhinitis.[2] The primary physiological manifestation of airways hyperresponsiveness is variable or reversible airflow obstruction. It is suggested that airflow variability be demonstrated by significant changes in the forced expiratory volume in one second (FEV_1) or the peak expiratory flow rate (PEFR). Airflow changes may occur spontaneously, with treatment, with a precipitating exposure, or with diagnostic maneuvers, such as nonspecific inhalation challenge.

[b]Patterns of association can be varied. The following examples are patterns that may suggest an occupational etiology: symptoms of asthma develop after a worker starts new job or after new materials are introduced on job (a substantial period of time may lapse between initial exposure and development of symptoms); symptoms develop within minutes of specific activities or exposures at work; delayed symptoms occur several hours after exposure, during the evenings of workdays; symptoms occur less frequently or not at all on days away from work and on vacations; symptoms occur more frequently on returning to work. Work-related changes in medication requirements may have similar patterns, also suggesting an occupational etiology.

[c]The number of agents and processes that have been associated with occupational asthma is large and constantly growing. Lists of agents are published in a number of references (*eg*, see references 2 and 3).

[d]Changes in nonspecific bronchial hyperreactivity can be measured by serial inhalation challenge testing with methacholine or histamine. Increased bronchial reactivity (manifested by reaction to lower concentrations of methacholine or histamine) following exposure and decreased bronchial reactivity after some time away from work is evidence or work-relatedness.

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APPENDIX A

Under the provisions of the Privacy Act of 1974 (5 U.S.C. §552a) we are required to provide the following information in relation to this form. The Centers for Disease Control, an Agency of the Department of Health and Human Services, is authorized to solicit this information under provisions of the Public Health Service Act, Section 301, (42 U.S.C. §241). Response in this case is voluntary, and there is no penalty for non-response. The information requested is considered relevant and necessary to the investigation of the health problems associated with hepatitis. The individually-identified data requested may be shared with health departments and other public health or cooperating medical authorities and will be used to establish the causes of the health problem and to make recommendations to resolve and prevent the recurrence of health problems of a similar nature. An accounting of such disclosures will be made available to the subject individual upon request.

388601

VIRAL HEPATITIS CASE RECORD

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Centers For Disease Control
Center For Infectious Diseases
Division of Viral Diseases
Hepatitis Branch
Bldg. 6, Rm. 154
Atlanta, Georgia 30333

STATE GEOGRAPHIC CODE (1) (2) (3) (4) (5)
STATE CASE NO. (8) (9) (10) (11)

DO NOT WRITE IN THIS BOX

YEAR (1) (2) (3)	QUARTER (4)	STATE (5) (6)	DIV
CDC CASE NO. (8) (9) (10) (11)		DATE RECEI	

PATIENT IDENTIFICATION

PATIENT'S LAST NAME (please print clearly) (12-26) FIRST AND MIDDLE NAME (or initial)

STREET ADDRESS TOWN OR CITY STATE (Zip Code) COUNTY (27-36)

AGE (37-38) Years ____ Date of Birth (39-44) Mo. Day Yr. SEX (45) 1 ☐ Male 2 ☐ Female RACE/ETHNICITY (46) 1 ☐ White, not of Hispanic Origin 2 ☐ Black, not of Hispanic 4 ☐ American Indian or Alaskan Native 5 ☐ Asian or Pacific Islander 6 ☐ His

DIAGNOSTIC AND CLINICAL DATA

Reporting physician's diagnosis: (47) 1 ☐ Hepatitis A (Infectious Hepatitis) 2 ☐ Hepatitis B (Serum Hepatitis) 3 ☐ Hepatitis Non-A, Non-B 4 ☐ Hepatitis Unspecified

	Mo	Day	Yr	
Date of first symptom:	___/	___/	___/	(48-53)
Date of diagnosis:	___/	___/	___/	(54-59)
Date of case report by physician:	___/	___/	___/	(60-65)

	YES	NO
Was the patient jaundiced? (66)	1 ☐	2 ☐
Was the patient hospitalized for hepatitis? (67)	1 ☐	2 ☐
Did the patient die as a result of hepatitis? (68)	1 ☐	2 ☐

LABORATORY RESULTS

	YES	NO	NOT TESTED FOR
Was the patient's serum positive for the IgM specific hepatitis A antibody (IgM anti-HAV)? (69)	1 ☐	2 ☐	8 ☐
Was the patient's serum positive for the hepatitis B surface antigen (HBsAG)? (70)	1 ☐	2 ☐	8 ☐
Was the patient's serum positive for the hepatitis B core antibody (anti-HBc) alone ("window")? (71)	1 ☐	2 ☐	8 ☐

EPIDEMIOLOGIC DATA

For purposes of National Surveillance, ASK ALL OF THE FOLLOWING QUESTIONS FOR EVERY CASE OF HEPATITIS. These questions may help determine where the patient acquired his/her infection. If "yes" answers are given for these risk factors, you may wish to obtain additional information to determine the patient's source of infection more precisely. Please refer to the work sheet on the back of the last page for additional questions.

HEPATITIS A AND HEPATITIS UNSPECIFIED RISK FACTORS

During the 6 weeks prior to onset of illness was the patient:

	YES	NO
1. a child or employee in a nursery, day care center, or preschool (72)	1 ☐	2 ☐
2. a household contact of a child or employee in a nursery, day care center, or preschool (73)	1 ☐	2 ☐
3. a contact of a confirmed or suspected hepatitis A case (74)	1 ☐	2 ☐
4. employed as a food handler (75)	1 ☐	2 ☐
5. suspected as being part of a common-source foodborne or waterborne outbreak (76)	1 ☐	2 ☐
6. an international traveller (77)	1 ☐	2 ☐

HEPATITIS B, HEPATITIS NON-A, NON-B, AND HEPATITIS UNSPECIFIED RISK FACTORS

During the 6 months prior to onset of illness was the patient:

	YES	NO
7. a contact of a confirmed or suspected hepatitis B or Non-A, Non-B case (78)	1 ☐	2 ☐
8. employed in a medical or dental field (79)	1 ☐	2 ☐
9. associated with a dialysis or kidney transplant unit (80) 1 ☐ patient 2 ☐ employee 3 ☐ contact of patient or employee (81)	1 ☐	2 ☐
10. known to have received blood or blood products (transfusion) (82) if yes, specify date(s) received. From (83-88) ___/___/___ to ___/___/___ ☐ (89-94)	1 ☐	2 ☐
11. hospitalized. (95)	1 ☐	2 ☐
if yes, was surgery performed (96)	1 ☐	2 ☐
12. attended by a dentist or oral surgeon (97)	1 ☐	2 ☐
13. known (or suspected) to self administer illegal drugs by injection (98)	1 ☐	2 ☐
14. known (or suspected) of having sexual relations with someone of the same sex (99)	1 ☐	2 ☐
15. known to have other percutaneous exposures (needle stick, ear piercing, tatooing, skin test, acupuncture, shots, etc.) (100)	1 ☐	2 ☐

Comments.

DATE OF INTERVIEW ☐☐ ☐☐ ☐☐ (101-1
Mo Day Yr

Investigator's Name and Title

WORK SHEET

For use by local health departments to determine the patient's most probable source of infection.

Patient's name _____ home phone _____ work phone _____

Patient's occupation _____ Employed by _____

Reporting physician's name, address, and phone # _____

_____

If patient was hospitalized for hepatitis, give name of hospital _____

POSSIBLE SOURCES FOR HEPATITIS A (2-6 weeks prior to onset)

If applicable:

1. Name, address, and phone # of child care center _____
2. Name, address, and phone # of known hepatitis A contact _____

   Relationship _____
3. Name, address, and phone number of restaurant where food handler worked _____

   _____
4. Name and address of school, grade, classroom attended _____
5. Name of foreign countries and dates visited _____

   _____ from _____ to _____
6. Food history of patient for the 2-6 weeks prior to onset:
   a. name and location of restaurants _____
   b. name and location of food stores _____
   c. name and location of bakery _____
   d. group meals attended (e.g., reception, church, meeting, etc.) _____

   _____
   e. raw oysters, mussels, or clams purchased from _____
7. Contacts: name | age | relationship to case | ISG

   _____
   _____
   _____
   _____
   _____

POSSIBLE SOURCES FOR HEPATITIS B AND NON-A, NON-B (during 6 months prior to onset)

If applicable:

1. Name of dialysis center associated with _____
2. Name of dentist or oral surgeon, if dental work performed _____
3. Name, address, and phone # of known hepatitis B contact _____

   Relationship _____
4. Name of hospital if hospitalized during 6 months prior to onset _____
5. Transfusion - associated case: (notify blood center)
   a. number of units of whole blood packed RBC or frozen RBC received _____
   b. specify type of blood product (e.g., albumin, fibrenogen, factor VIII, etc.) _____
   c. name of center where blood was obtained _____
6. History of blood donation or plasmapheresis:
   a. name of facility _____
   b. date(s) of donation _____
7. Specify other percutaneous exposures _____

COMMENTS

_____

DATA AND TRENDS AFFECTING MICHIGAN PHYSICIANS ISSUE 4 MAY 1991

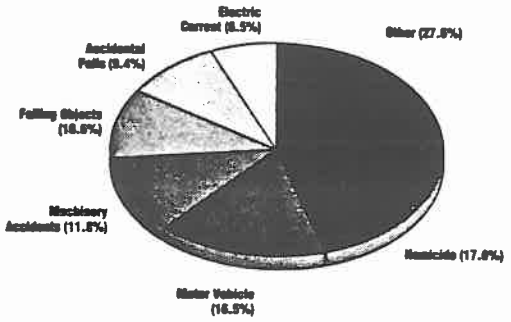
Medical Inquirer

OCCUPATIONAL DISEASE IN MICHIGAN

There are no reliable national or state surveillance systems for occupational disease.[1] Most workers who develop occupational disease do not apply for worker's compensation. The following estimates of occupational disease in Michigan are based on extrapolations from disease reports to state health departments[2,3,4], death certificates, hospital discharge data[5,6], worker compensation data[7], reports from employers[8], and surveys reported in the medical literature[9,10]. The estimates presented here probably underestimate the true burden of occupational disease in Michigan.

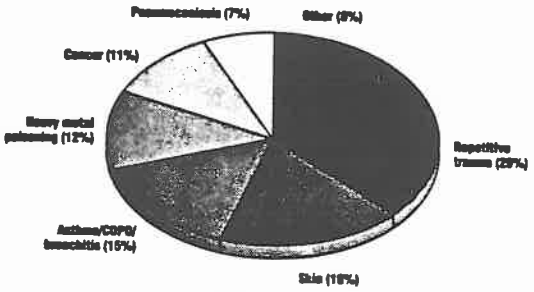
MICHIGAN ACUTE WORK-RELATED FATALITIES BY CAUSE 1988

There are approximately 170 acute work-related fatalities noted annually on death certificates in Michigan. Additionally, for 10 percent of cancer deaths, for one to three percent of chronic respiratory disease, and for one to three percent of cardiovascular deaths, occupation is estimated to be a significant contributor. This is equal to approximately 3,000 deaths per year out of a total of 80,000 Michigan deaths per year.



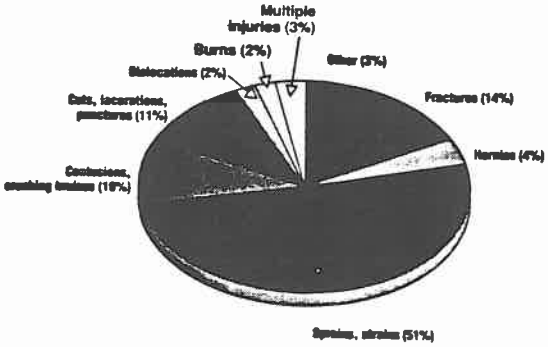
MICHIGAN WORK-RELATED ILLNESSES BY DISEASE TYPE 1988

An estimated 12,000 to 14,000 workers develop new occupational diseases per year in Michigan.



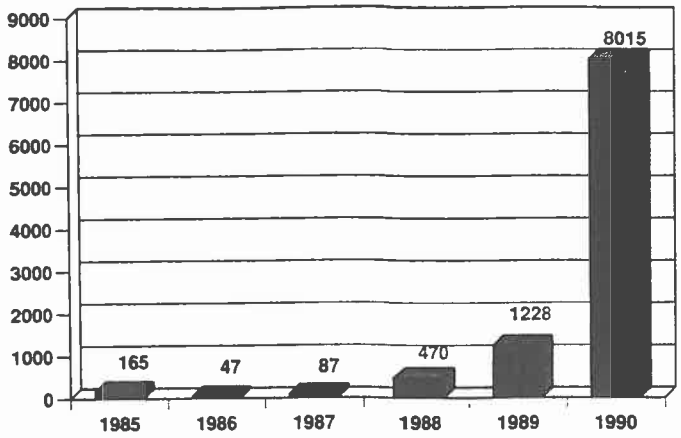
MICHIGAN NON-FATAL INJURIES BY TYPE OF INJURY 1988

An estimated 74,500 to 230,700 non-fatal workplace injuries occur each year in Michigan. The low estimate is based on state worker compensation records. The high estimate is based on data supplied by employers to the Michigan Department of Labor.



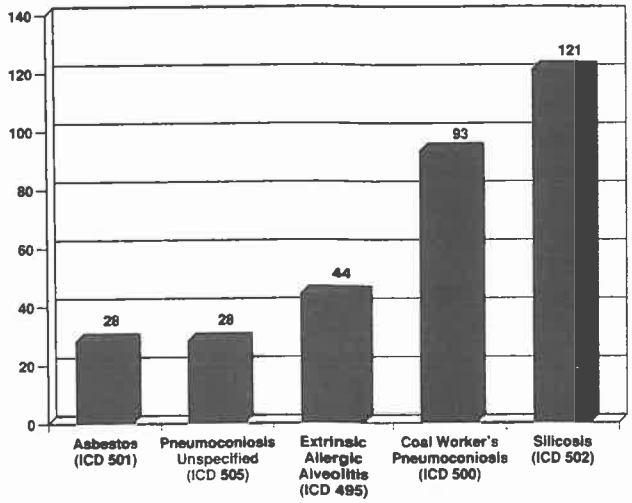
OCCUPATIONAL DISEASE REPORTS TO THE STATE HEALTH DEPARTMENT MICHIGAN 1985-1990

Physicians, hospitals, clinics and employers are required to report occupational disease (not injuries) to the Michigan Department of Public Health (MDPH). Since 1988, MDPH has been reminding physicians and hospitals of the reporting requirements.



HOSPITAL DISCHARGE DIAGNOSES PER YEAR FOR THE PNEUMOCONIOSES AND EXTRINSIC ALLERGIC ALVEOLITIS, MICHIGAN 1982-1988

Hospital discharge data can be used to identify the definite occupational diseases, pneumoconiosis and extrinsic allergic alveolitis. There are approximately 300 hospital discharges for occupational lung disease per year. It is estimated there are two non-hospitalized patients for every hospitalized patient, or 900 newly diagnosed Michigan residents with pneumoconiosis each year. ■



Prepared by Kenneth D. Rosenman, M.D., Associate Professor of Medicine, Michigan State University.

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Medical Inquirer

DATA AND TRENDS AFFECTING MICHIGAN PHYSICIANS

A publication of the Michigan State Medical Society Department of Medical Economics and Health Care Delivery

CENTERS FOR DISEASE CONTROL

MMWR

MORBIDITY AND MORTALITY WEEKLY REPORT

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143 Third National Injury Control Conference

Effectiveness in Disease and Injury Prevention

Control of Excessive Lead Exposure in Radiator Repair Workers

In 1988, 83 automotive repair workers with blood lead levels (BLLs) >25 μg/dL were reported to state health departments in the seven states* that collaborated with CDC's National Institute for Occupational Safety and Health (NIOSH) in maintaining registries of elevated BLLs in adults. In 18 (22%) of these 83 persons, BLLs were >50 μg/dL†. Among automotive repair workers for whom a job category was specified, radiator repair work was the principal source of lead exposure. The major sources of exposure for radiator repair workers are lead fumes generated during soldering and lead dust produced during radiator cleaning (*2*). This report summarizes current BLL surveillance data for radiator repair workers and describes three control technologies that are effective in reducing lead exposures in radiator repair shops.

Airborne lead levels as high as 500 μg/m^3 (10 times greater than the Occupational Safety and Health Administration [OSHA] permissible exposure limit [PEL] of 50 μg/m^3) have been reported in small radiator repair shops (*3*). Engineering controls in such facilities typically consist of wall- or roof-mounted propeller fans, which provide general area ventilation, or electrostatic precipitators suspended from the ceiling, which remove airborne particulates (*2*). However, neither method reduces worker lead exposures to levels below the OSHA PEL. In 1989, to meet the need for effective engineering controls in radiator repair shops, NIOSH researchers studied three exhaust-ventilation control systems for radiator shops. Each of the three local control systems effectively reduced radiator repair workers' lead exposures to levels substantially below the OSHA PEL. The performance of each control system was documented by collecting personal breathing-zone samples for lead and by measuring local exhaust-ventilation system airflow capacities.

Ventilated Enclosure

An enclosure resembling a laboratory hood surrounds the workstation (*4*). The enclosure's walls are curtains of silicone-coated fibrous glass cloth, which have a temperature rating of 1000 F (538 C), cannot be set on fire by a mechanic's torches, and will not corrode. The curtains are suspended from the building's ceiling and extend to the top outer edges of a water bath (used to leak-test radiators). The ceiling forms the top of the enclosure; the back wall of the building, which has a propeller exhaust fan, forms the rear wall. A 3-foot by 3-foot opening in the front of the enclosure permits the mechanic access to repair the radiator, which remains within the enclosure. The fan exhausts air at a rate of 2000 cubic feet per minute (cfm), producing an air flow of 200 feet per minute (fpm) through the enclosure opening.

The approximate cost of the enclosure was $1000 (1990 dollars), which included structural materials, installation, and a wall-mounted axial fan with motor. During the study of this system, lead exposures for the radiator repair worker using the ventilated enclosure averaged 9.9 μg/m^3. Comparison personal breathing-zone sam-

Lead Exposure — Continued

ples obtained from a radiator repair mechanic in the same shop who worked at an identical workstation without ventilation control averaged 453 $\mu g/m^3$.

Movable Exhaust Hood

A canopy-shaped exhaust hood with a 24-inch by 36-inch opening is connected to an 8-inch diameter flexible duct that permits the hood to be moved directly to the work that generates lead fume. The face velocity at the hood opening is approximately 100 fpm. The cost of the hood and duct work for each workstation was $1000 (1990 dollars). Lead exposures for the busiest mechanic averaged 12 $\mu g/m^3$. In comparison, personal sampling data collected at this shop by the Virginia Occupational Safety and Health Department before the exhaust hood installation found time-weighted average lead exposures for workers at levels as high as 193 $\mu g/m^3$ (R.D. Mitchell, Virginia Occupational Safety and Health Department, personal communication, December 20, 1988).

Ventilated Booth

A shop owner, using design information provided by NIOSH, relocated the shop's two existing radiator repair benches against an outside wall and enclosed them in a booth. Cement-block walls form the sides, a welding curtain encloses the top of the booth, and a strip of plastic across the bottom 3 feet of the front of the booth creates a front opening 11.5 feet wide by 4 feet high. An axial, belt-driven fan (exhaust capacity 14,000 cfm) was installed in the outside wall at the rear of the booth, which produced a 250 fpm face velocity airflow through the front opening. The cost of the control system, including materials and labor, for two workstations was approximately $2200 (1990 dollars); this included a set of high-intensity lights costing $250. The average lead exposure for radiator repair workers using this system was 9 $\mu g/m^3$, a reduction of 91% compared with an average lead exposure of 98 $\mu g/m^3$ (range: 30–220 $\mu g/m^3$) measured during a NIOSH health hazard evaluation conducted before installation of the control (*5*).

Reported by: A Miller, MD, Occupational Health and Safety Center, Univ of Illinois at Chicago. Div of Physical Sciences and Engineering, Div of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, CDC.

Editorial Note: The manifestations of symptomatic lead poisoning (convulsions, coma, neuropathy, nephropathy, anemia, and abdominal colic) generally occur at BLLs >80 $\mu g/dL$. Adverse health effects at lower BLLs include inhibition of heme production, peripheral neuropathy, male and female reproductive dysfunction, and hypertension (*6*). In occupational settings, absorption of lead results primarily from exposure to lead dust and fumes. Data from the National Occupational Exposure Survey, conducted during 1981–1983, indicated that approximately 827,000 U.S. workers have potential work-related exposure to lead (excluding those with exposure to lead in gasoline) (*7*). Workplace exposure also has been described as a vector for childhood and community lead exposure through contamination of work clothing (*8*).

Current estimates indicate that approximately 435,000 workers are employed in the automotive repair industry (*9*); an estimated 40,000 are involved specifically in radiator repair work, with an average of four workers in each shop (W.H. Juchno, National Automotive Radiator Service Association, personal communication, March 15, 1990). Studies in a variety of settings indicate that lead exposure is substantial in these workers. For example, in Finland, the mean BLL in 56 radiator repair workers was 38 $\mu g/dL$, which represented the sixth highest value among 30 occupational categories (*10*). NIOSH health hazard evaluations conducted from 1979

*California, Colorado, Maryland, New Jersey, New York, Texas, and Wisconsin.

†Under the Occupational Safety and Health Administration lead standard, BLLs exceeding an average of 50 $\mu g/dL$ on three separate occasions in a 6-month period require medical removal of the employee from the workplace (*1*).

Lead Exposure — Continued

through 1990 at radiator repair shops in California, Colorado, and Georgia found that, among 46 radiator repair workers, 68% had lead exposures exceeding the OSHA PEL, 83% had BLLs ≥30 μg/dL, and 26% had BLLS ≥50 μg/dL. Finally, among 56 radiator repair mechanics in the Boston area, 80% had BLLs >30 μg/dL, and 16% had BLLs >50 μg/dL (*2*).

By applying representative BLL findings from these studies to the estimated 40,000 U.S. radiator workers, BLLs in approximately 32,000 (80%) workers exceed 30 μg/dL, BLLs in 16,000 (40%) exceed 40 μg/dL, and BLLs in 8400 (21%) exceed 50 μg/dL. Based on this approach, the 83 cases of elevated BLLs reported to the seven state health departments in 1988 represent a substantial underestimation of the prevalence of this condition.

In general, environmental monitoring and medical surveillance for lead exposure in radiator repair workers is inadequate. For example, in California in 1986, only 1.4% of these workers were employed in positions where environmental monitoring was ever done; only 7.9% of the surveyed radiator repair shops performed any routine biologic monitoring (*11*). Inadequate medical surveillance of these workers can result in substantial underestimation of the number of workers at risk for lead toxicity and further underscores the need for both improved monitoring and effective engineering controls to protect the health of these workers. The three economic and effective ventilation control systems described in this report have potential for widespread application in relatively small radiator shops that lack resources for purchase of elaborate ventilation systems.[5]

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[5]To obtain the latest reports on engineering controls for radiator repair shops, contact John W. Sheehy, NIOSH, CDC, Mailstop R-5, 4676 Columbia Parkway, Cincinnati, OH 45226; telephone (513) 841-4221.

CENTERS FOR DISEASE CONTROL

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Lead Poisoning among Bricklayers — Washington State

In May 1989, four members of an 11-man crew of bricklayers in western Washington state developed symptomatic lead poisoning while replacing the brick lining of an acid-accumulation tank at a paper mill. Peak blood lead levels (BLLs) for the four workers ranged from 88 to 123 µg/dL.* An investigation indicated the source of the lead exposure was a special brick mortar that contained 71% lead oxide and was formulated to resist the normally acidic environment of the tank.

The cylindrical acid-accumulation tank was 50 feet tall and 20 feet in diameter; the enclosed top had an access portal 3 feet in diameter. In April 1989, after removal of the old lining, bricklaying for the new lining began. The mortar was prepared outside of the tank by mixing dry mortar powder with water. The mixed mortar, along with new bricks, was then passed through the access portal to bricklayers working in the tank.

On May 4 (approximately 3 weeks after starting the job), the worker who mixed the mortar had onset of fatigue and abdominal pain and left work. His replacement developed headaches, chest pain, and abdominal pain within 2 days of assuming the mixing job. The workers independently sought medical care and reported the possibility of lead poisoning to their physicians on May 4 and 6, respectively. Elevated BLLs (112 µg/dL and 92 µg/dL, respectively) were documented in the two workers. In addition, the first worker was anemic (hematocrit of 31%), and he received a partial course of chelation therapy with oral penicillamine. There were no records of either case being reported to the local or state health departments.

Following recognition of these cases, the subcontractor who had employed the bricklayers introduced changes at the worksite, including improvement of safety training, construction of a separate shed for mixing mortar, provision of facilities to enable workers to shower before lunch and at the end of the work shift, and replacement of paper masks with appropriate forms of respiratory protection (including supplied-air respirators for use during mortar mixing). On May 11, the Washington Department of Labor and Industries (L&I), in response to a worker request, inspected the worksite and found no violations. Following the inspection, however, the project foreman became ill, was diagnosed with lead poisoning (initial BLL: 88 µg/dL), and, on May 15, was hospitalized for 2 days for chelation therapy with intravenous calcium ethylenediaminetetraacetic acid (EDTA). Finally, on May 19, a fourth crew member, who worked as both a bricklayer and a mortar mixer, became ill and consulted a physician; his highest BLL was 123 µg/dL, and he was treated with oral penicillamine. The relining operation was completed in June.

In August 1989, the University of Washington Occupational Medicine Program conducted a follow-up investigation of this outbreak after an affected worker was referred by L&I for independent medical examination. The investigation identified several deficiencies in the protection and monitoring of this group of workers, including the lack of air sampling at the worksite and the failure to test BLLs in workers who may have had excessive lead exposure but did not report symptoms.

*Under the Occupational Safety and Health Administration lead standard, BLLs exceeding 60 µg/dL on a single occasion or an average of 50 µg/dL on three separate occasions in a 6-month period require medical removal of the employee from the worksite (1).

Lead Poisoning — Continued

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Editorial Note: Acute lead poisoning in a worker whose job entails exposure to lead is considered an occupational sentinel health event (i.e., a condition that indicates both the failure to protect that worker from a preventable occupational illness and the existence of risk of similar illnesses for co-workers [*2*]). Adherence to appropriate workplace controls can prevent exposures to lead, while surveillance systems for identifying workers with elevated BLLs (ideally before they have become symptomatic) permit the targeting of intervention efforts (*3*). Treatment of lead poisoning always requires removal from exposure; chelation therapy (e.g., with intravenous EDTA) is generally reserved for symptomatic patients (*4*). State or local reporting and intervention systems can provide physicians access to consultation and expertise in diagnosis and treatment of clinical lead poisoning.

Environmental and biologic monitoring are usually necessary to evaluate the effectiveness of attempts to control exposure to lead. Consequently, the Occupational Safety and Health Administration (OSHA) lead standard for general industry specifies a permissible exposure level (PEL) of 50 $\mu g/m^3$ in air and mandates environmental and biologic monitoring under specified circumstances[†] (*1*). The construction industry, however, is exempt from the general industry standard; instead, it is covered by the OSHA standard for construction, which specifies a PEL of 200 $\mu g/m^3$ but contains no requirements for routine environmental or biologic monitoring (*5*).

When preventable exposures to lead result in poisoning(s), effective surveillance systems are essential in preventing additional cases. Laboratory-based reporting systems, which rely on routine mandatory reporting of elevated BLLs by laboratories, can trigger timely follow-up and intervention activities. Advantages of these surveillance systems are that 1) implementation is straightforward because the systems rely on existing requirements and medical practice; 2) use of a laboratory test improves the reliability of case identification; 3) more precise targeting of prevention activities is possible; and 4) the health departments managing these systems can readily serve as resources for information on prevention, follow-up, and appropriate treatment of persons with lead toxicity. In conjunction with CDC's National Institute for Occupational Safety and Health (NIOSH), 14 states[§] have implemented or are developing laboratory-based systems for reporting elevated BLLs (*6*). These systems have been effective in identifying worksites with excess lead exposure and co-workers at risk for lead poisoning (*3,6*).

For at least two reasons, workers with excessive exposure to lead may not be identified until they are diagnosed with symptomatic lead poisoning. First, surveillance systems depend on compliance with requirements for medical monitoring of lead-exposed workers; consequently, in worksites that fail to perform routine medical monitoring, exposures may not be detected. Second, excessive exposures to lead in the construction industry are frequently undetected because medical monitoring is not required. In these circumstances, case reports submitted by physicians to organized surveillance and prevention programs can trigger a public health response.

[†]When airborne lead concentrations exceed 30 $\mu g/m^3$ (averaged during an 8-hour workshift), employers must provide an industrial hygiene program and medical surveillance (including monitoring of BLLs).

[§]Alabama, California, Colorado, Connecticut, Illinois, Maryland, Massachusetts, Michigan, New Jersey, New York, Oregon, Texas, Utah, and Wisconsin.

Lead Poisoning — Continued

Despite underreporting by physicians, such reports may be the only means for timely recognition of and response to lead poisoning in workers and other sentinel health events.

The national health objectives for the year 2000 have targeted the elimination of occupational exposures to lead that result in BLLs ≥25 μg/dL (7). To meet this objective, NIOSH encourages states to establish lead surveillance systems and advocates a coordinated approach involving federal, state, industry, labor, and trade groups.

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Notice to Readers

Fetal Alcohol Syndrome Conference

"Fetal Alcohol Syndrome and Other Congenital Alcohol Disorders: A National Conference on Surveillance and Prevention" will be held in Atlanta on April 1–3, 1991. The conference is cosponsored by CDC's Center for Environmental Health and Injury Control (CEHIC); the Indian Health Service; the Alcohol, Drug Abuse, and Mental Health Administration's Office for Substance Abuse Prevention and National Institute on Alcohol Abuse and Alcoholism; the Association for Retarded Citizens; the March of Dimes Birth Defects Foundation; and the National Organization for Fetal Alcohol Syndrome.

Information about the conference is available from the Division of Birth Defects and Developmental Disabilities, CEHIC, CDC, Mailstop F-37, 1600 Clifton Road, NE, Atlanta, GA 30333; telephone (404) 488-4707 or FTS 236-4707.

NIOSH Reports

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NIOSH Alert: Request for Assistance in Preventing Lead Poisoning in Construction Workers. DHHS (NIOSH) Publication No. 91-116

NIOSH Alert: Preventing Electrocutions During Work With Scaffords Near Overhead Power Lines. DHHS (NIOSH) Publication No. 91-110.

Work Related Lung Disease Surveillance Report.
DHHS (NIOSH) Publication No. 91-113.

AIHA JOURNAL

Applications & Reviews

AM. IND. HYG. ASSOC. J. 53(1):42–48 (1992)

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Silica Exposure in Hand Grinding Steel Castings*

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Exposure to silica dust was studied in the grinding of castings in a steel foundry that used conventional personal sampling methods and new real-time sampling techniques developed for the identification of high-exposure tasks and tools. Approximately one-third of the personal samples exceeded the National Institute for Occupational Safety and Health recommended exposure limit for crystalline silica, a fraction similar to that identified in other studies of casting cleaning. Of five tools used to clean the castings, the tools with the largest wheels, a 6-in. grinder and a 4-in. cutoff wheel, were shown to be the major sources of dust exposure. Existing dust control consisted of the use of downdraft grinding benches. The size of the casting precluded working at a distance close enough to the grates of the downdraft benches for efficient capture of the grinding dust. In addition, measurements of air recirculated from the downdraft benches indicated that less than one-half of the respirable particles were removed from the contaminated airstream. Previous studies have shown that silica exposures in the cleaning of castings can be reduced or eliminated through the use of mold coatings, which minimize sand burn-in on the casting surface; by application of high-velocity, low-volume exhaust hoods; and by the use of a nonsilica molding aggregate such as olivine. This study concluded that all these methods would be appropriate control options.

As part of the intervention phase of the New Jersey Department of Health (NJDOH) silicosis surveillance program,[1–3] the Occupational Health Service (OHS) conducts follow-up investigations at all companies identified as having one or more cases of silicosis. As a result of several reported cases of silicosis, a site visit to a steel foundry was conducted. The visit revealed potential employee overexposure to crystalline silica throughout the plant. In November 1989, researchers from the Engineering Control Technology Branch (ECTB) of the National Institute for Occupational Safety and Health (NIOSH) conducted a joint study of this facility with NJDOH. The purpose of this study was to determine if current workers were at risk of developing silicosis by identifying and evaluating worker exposures to silica-containing dusts; to evaluate and recommend improvements in current engineering controls and work practices so that future cases of silicosis could be eliminated; and to determine if these recommended control measures could be applied in similar situations. Because the largest number of workers was engaged in casting cleaning, this area of the foundry received special attention.

Grinding of ferrous castings has long been associated with overexposure to crystalline silica.[4–8] These studies indicated that about one-third of grinding personnel are exposed to free silica in excess of the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL).

*Disclaimer: Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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Hand-held grinders are used in the cleaning rooms of foundries to remove gate and riser connections, parting-line fins, and other imperfections from large castings. The grinding operation produces a dust cloud in the breathing zone of the operator. The major dust hazard in grinding castings arises from the molding sand, which adheres to the casting surface. Even when castings have been well cleaned by blasting with steel shot, the surface will still contain some silica from the molding sand. When the casting is ground, this silica is shattered and part of it becomes airborne. Large particles leave the wheel more or less tangentially from the point of contact with the casting. Smaller particles are entrained in the wake of these large particles. Other fine particles do not separate appreciably from the wheel and are contained in a layer of air close to the wheel.[9]

PLANT DESCRIPTION

This plant was a captive foundry producing steel and stainless steel castings. Production was divided into approximately 40% steel and 60% stainless steel castings. Induction furnaces were used to melt and adjust the alloys. The foundry produced molds with an alkyd-oil (drying oil/isocyanate) molding system. Zircon- and silica-based washes were used on molds and cores. In general, patterns were waxed to facilitate mold removal, although some nonsilica parting compounds were used. After shakeout and cooling, large casting appendages were removed by means of an oxygen torch in one of two ventilated booths; remaining extraneous material was removed by an arc-air torch in a second booth. A swing frame grinder and cutoff saw (both contained in booths) also were used. Castings were cleaned automatically by steel shot in an abrasive blasting machine or manually by sand blasting in a walk-in cabinet. Additional material was removed from castings primarily by hand-held grinders used on downdraft benches. These benches recirculated filtered air back into the foundry. The benches consisted of L-shaped plenum chambers and metal gratings on which the castings were placed. Flow rates for the grinding benches (measured 150–300 ft/min) were generally above those recommended (150–250 ft/min) in the American Conference of Governmental Industrial Hygienists (ACGIH) publication *Industrial Ventilation: A Manual of Recommended Practice*.[10] The lower part of this plenum supported the grating and served as a drop-out chamber for cleaning debris. The upper section contained primary and secondary sets of filters (efficiency rating unknown), followed by a propeller fan.

METHODOLOGY

A three-part strategy was employed to evaluate the silica risk and to identify control options for the cleaning of castings. First, 15 personal samples for crystalline silica and respirable dust were collected to estimate the exposure to workers who performed chipping and grinding operations using hand-held tools. Second, real-time measurements were made on two workers to determine which tools and procedures were the primary exposure sources so that control efforts could be prioritized. Last, the removal efficiency of the air recirculation system employed in the downdraft benches was measured. The latter procedure was undertaken to determine if dust captured by the bench was re-entering the work room.

Silica Dust

Time-integrated samples were collected in the breathing zone of hand grinder operators for a full-day shift generally lasting about 7 hr (depending on individual work schedules). Workers were sampled for three consecutive days. These samples were collected on preweighed, 37-mm (diameter), 5-µm (pore size) PVC membrane filters (FWSB, Mine Safety Appliances, Pittsburgh, Pa.) mounted in series with 10-mm nylon cyclones (Mine Safety Appliances). Air was drawn through the filter at a flow rate of 1.7 L/min by using battery-powered sampling pumps (Air Check Sampler, Model 224-PC X R7, SKC Inc., Eighty Four, Pa.).

All filter samples were weighed according to NIOSH Method 0500 and analyzed for crystalline silica content by x-ray diffraction with a modification of NIOSH Method 7500.[11] These modifications were as follows. (1) Quartz quantities were calculated by using secondary quartz standards and the sample's secondary peak intensity. (2) Cristobalite quantities were calculated by measuring primary peak height values of the cristobalite standards and the samples rather than by using the integrated peak areas. The limit of detection (LOD) and the limit of quantification (LOQ) for the samples were 0.015 mg and 0.03 mg per sample, respectively, for both quartz and cristobalite.

Real-Time Measurements

Sampling and analytical methods currently used for fibrogenic dusts are, for the most part, limited to long sampling periods. To determine when dust was generated and which specific tasks or tools were responsible, air sampling was complemented by real-time dust exposure measurements and video recordings.[12] These measurements were made on workers performing chipping and grinding operations in order to determine the relative exposure caused by different tools and operations and to examine the possibility of control by using high-velocity, low-volume (HVLV) exhaust hoods. The instrument used to measure dust concentration was a hand-held aerosol monitor (HAM, PPM, Knoxville, Tenn.). This instrument is a light-scattering device; its response is dependent upon the optical characteristics of the dust being measured. The HAM responds to respirable dust but does not differentiate between crystalline silica and other dusts. The analog output of the HAM was connected to a data logger (Rustrak Ranger, Gulton, East Greenwich, R.I.). When the data collection was completed, the data from the data logger were downloaded to a portable computer (Compaq Portable II, Compaq Computer Corporation, Houston, Tex.) for analysis.

Two workers volunteered to participate in the real-time monitoring. Each worker selected a casting that required the use of a variety of tools. One selected a pump housing; the other selected an impeller. Each worker used a 6-in. horizontal radial wheel grinder (6000 rpm), a 4-in. cutoff wheel (15 000 rpm), and a 3/8-in. diameter burr mounted on a 16-in. extension (18 000 rpm). The worker cleaning the impeller also used a cone wheel mounted on the same type of tool as the 4-in. cutoff wheel. Each tool was pneumatically

powered and the tool exhaust was unmuffled. Dust exposures and video recordings were made for 30 min on each worker.

Exhaust Air Recirculation

The performance of exhaust air recirculation systems was evaluated by using a Royco portable optical particle counter (Royco Instruments, Menlo Park, Calif.). This instrument counts and sizes dust particles by measuring the amount of light scattered as individual particles enter a sensing volume. A single-channel pulse analyzer allows all particles greater than a selected size to be counted. By repeated measurements at different minimum sizes, a particle size distribution can be obtained.

Particle size distribution measurements were made at the inlet and outlet of two grinding benches to determine the removal efficiency of the filter system. The design of the bench precluded the collection of a representative sample during grinding: dust from the grinders was projected into a short plenum connected directly to the filter chamber, which did not permit uniform mixing of the dust with the exhaust air. In addition, the grinding operation did not produce dust at a constant rate. Because of these difficulties, bench performance was measured by using the ambient aerosol present in the casting cleaning department as the test aerosol. Use of ambient aerosol as a challenge dust is a technique that has been used in respirator fit testing.[13] The fan of the first bench was on at the time of the test and visual inspection of the filters indicated that they were intact. The second bench had secondary filters missing, and the fan was first switched on about 5 min before the test.

RESULTS

Silica Exposure

Of the 15 personal samples, 4 exceeded the NIOSH recommended exposure limit[14] (REL) of 50 μg/m³ for quartz; none exceeded the OSHA PEL[15] of 100 μg/m³ for quartz. One sample exceeded both the REL and PEL for cristobalite (50 μg/m³) by a factor of 2; all of the remaining air samples collected contained no detectable respirable quartz or cristobalite, corresponding to an airborne concentration of approximately <20 μg/m³. Table I summarizes the results of the crystalline silica and respirable dust measurements.

TABLE I. Worker Exposure to Respirable Crystalline Silica and Respirable Dust

Grinder	Time (min)	Mass (mg/m³)	Quartz (μg/m³)	Cristobalite (μg/m³)
0	424	0.9	47	ND[A]
0	433	0.7	69[B]	ND
1	410	0.2	ND	ND
2	412	0.7	97[B]	ND
2	438	0.8	ND	ND
3	419	0.4	ND	ND
3	438	2.2	91[B]	94[B]
4	415	1.1	48	ND
4	435	1.0	46	ND
5	421	0.3	ND	ND
5	435	0.7	69[B]	27
6	416	0.2	48	ND
7	433	0.5	46	ND
8	419	0.4	ND	ND
9	420	0.2	ND	ND

[A]ND: none detected.
[B]Values in excess of NIOSH REL.

Exposure Sources

Real-time dust exposure data were overlayed as a moving bar onto the video recording[16] and viewed for preliminary determination of the activities that may have affected exposure. This review indicated that the type of tool used, the direction of the grinding swarf (the stream of glowing metal particles), and the position of the tool (inside or outside of the casting) caused

TABLE II. Summary of Real-Time Dust Exposure Measurements

Exposure Source	Concentration (mg/m³)	Time (sec)	Integrated Exposure (mg/m³-min)
Casting: Pump Housing			
Tool			
6-in. grinder	5.1	375	32
4-in. wheel	7.1	470	55
Burr grinder	0.9	165	2
Other activities	0.9	470	7
Tool Location			
Inside casting	5.7	505	48
Outside casting	4.9	505	41
Other activities	0.9	470	7
Swarf Direction			
Up	8.6	340	49
Down	1.4	175	4
Away	4.9	230	19
Toward	9.4	100	16
Undetermined	0.9	635	10
Casting: Impeller			
Tool			
6-in. grinder	1.5	270	7
4-in. wheel	0.1	270	1
Burr grinder	0.2	375	1
Cone grinder	0.5	395	3
Other activities	0.2	215	1
Tool Location			
Inside casting	0.3	1040	5
Outside casting	1.5	270	7
Other activities	0.2	215	1
Swarf Direction			
Up	0.2	20	0
Down	0.9	240	3
Toward	6.7	30	3
Undetermined	0.3	1235	6

noticeable exposure differences. To estimate the extent to which these variables affected exposure, the real-time data were assembled into a commercial spreadsheet consisting of time, exposure, and activity for each 5-sec time period. The exposure measurements were "slipped" 5 sec with respect to the time and activities to allow for instrument delay. The average exposure, the time, and the cumulative exposure (the product of concentration and time) were calculated for each of the activity variables.

Summary data are presented in Table II. The average dust concentration for each tool type and the percentage of the time each tool was used are presented in Figure 1. During cleaning of the pump housing, dust concentrations were highest for the 6-in. grinder and the 4-in. cutoff wheel. For the impeller, dust concentrations were highest for the 6-in. grinder and the cone grinder. The cone grinder was not used on the pump housing. The cumulative exposure is described graphically in Figure 2 as a function of tool type, tool location, and swarf direction. The cumulative exposure was almost an order of magnitude greater for the pump housing than for the impeller. The 4-in. cutoff wheel was the greatest contributor (57%) to cumulative exposure for the worker cleaning the pump housing; the 6-in. grinder was the greatest contributor (54%) to the cumulative exposure for the worker cleaning the impeller. Cleaning the inside of the casting appeared to have a beneficial effect on cumulative exposure for the case of the impeller: although the worker spent about five times as long cleaning the inside of the casting as the outside, inside cleaning only resulted in about 39% of the total cumulative exposure for this worker. This beneficial effect may be caused by the impeller diffusing the grinding swarf. Swarf direction appeared to be a major exposure factor: for the pump housing, concentrations ranged from highest to lowest in the order of "toward," "up," "away," "down," and "undetermined." For the impeller, only minimal periods were observed where the swarf was directed "up," or "away."

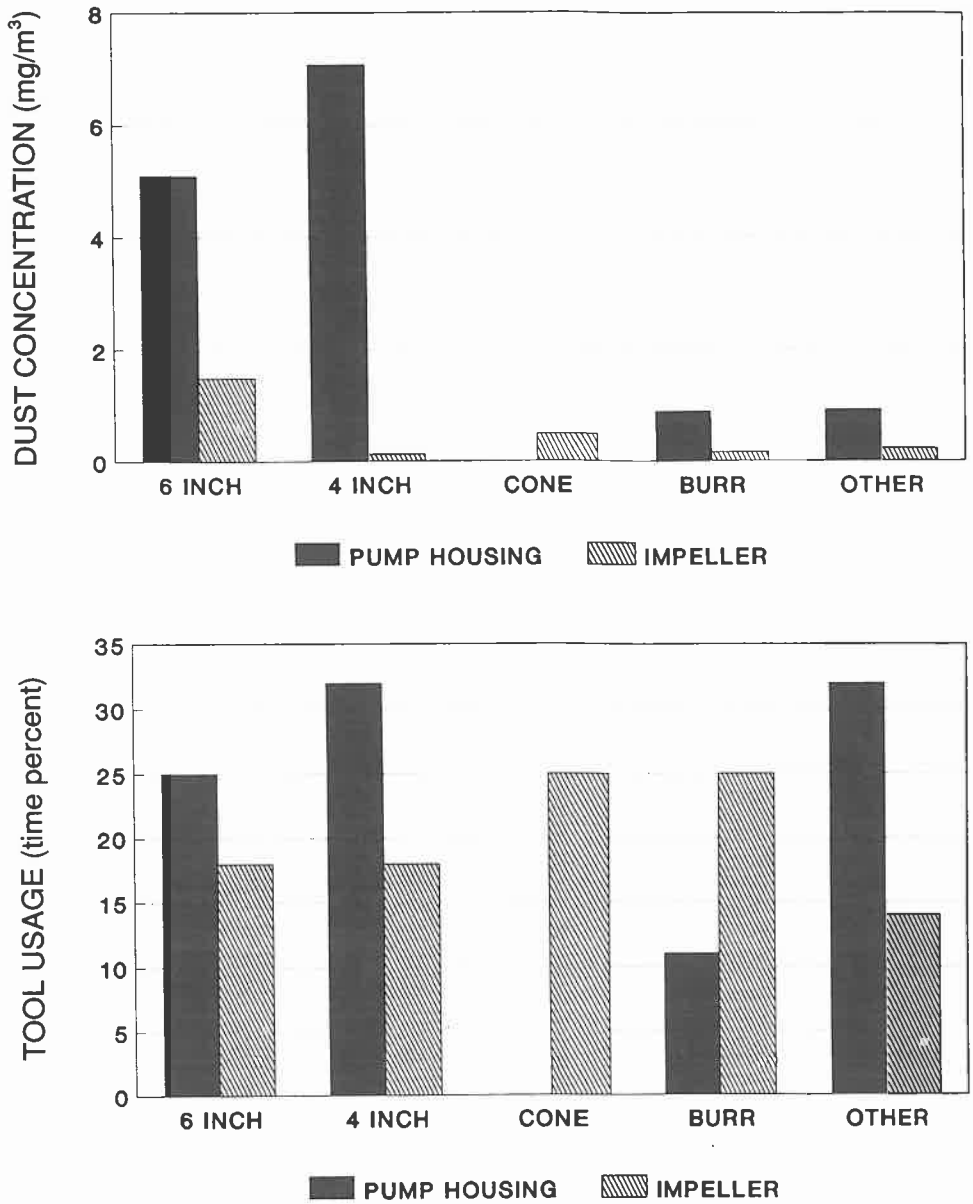

FIGURE 1. Average dust exposure and tool usage during the cleaning of the pump housing and impeller castings

Because not all combinations of variables were present, each existing combination was assigned as an individual independent variable (combination of tool, position, and swarf direction) for statistical analysis. The logarithm of the exposure was the dependent variable. The SAS General Linear Models Procedure[17] was used to fit the data. The Ryan-Einot-Gabriel-Welsch (REGW) Multiple Range Test[18] was used to determine if significant differences (alpha = 0.05) existed between the log mean exposure for each independent variable. The results of the analyses are presented in Table III. The combinations of tool, grinding location, and swarf direction are listed in order of exposure from highest (top) to lowest (bottom). Those combinations with the same letter assigned by the REGW test are not significantly

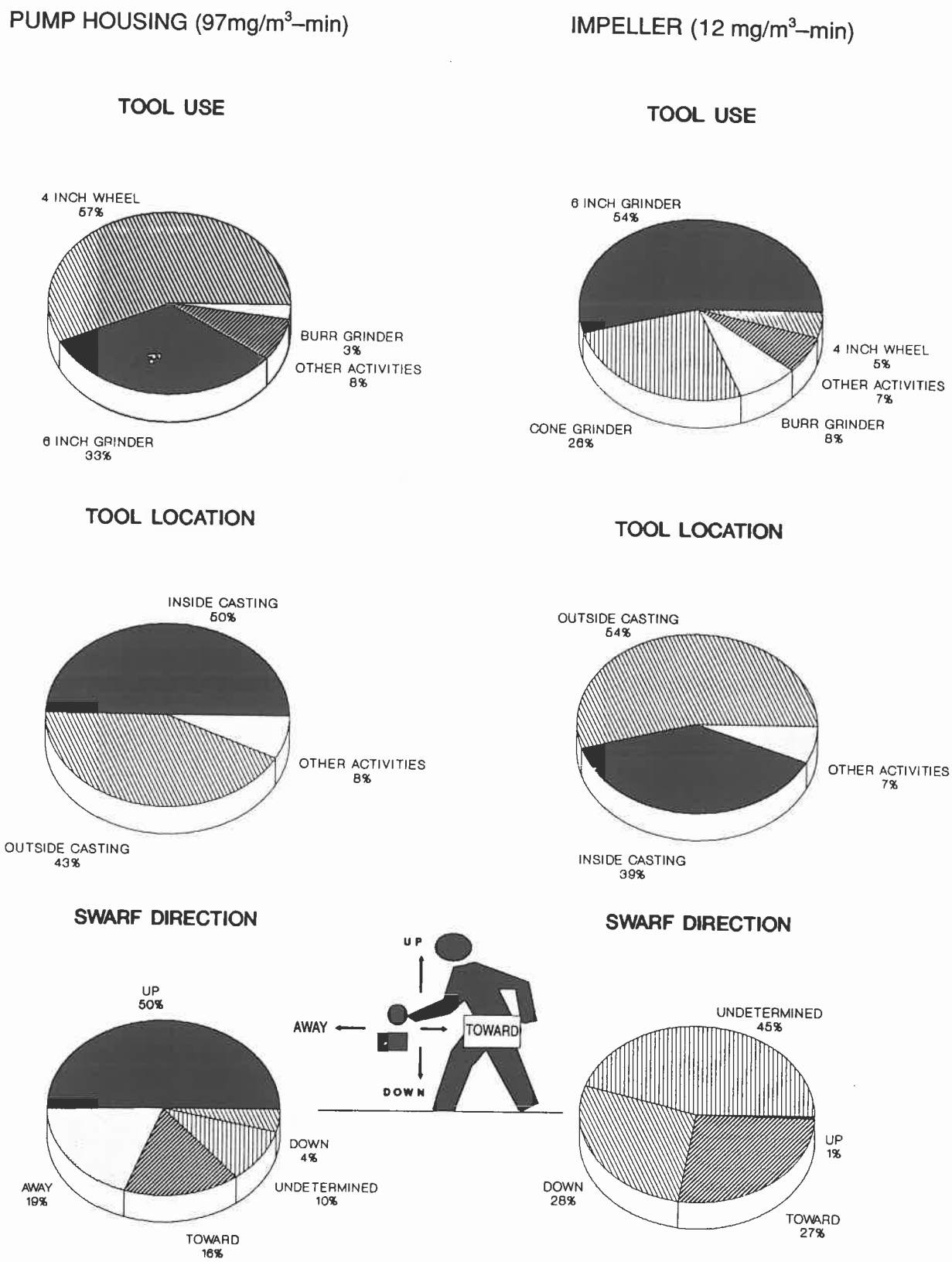

FIGURE 2. Analysis of dust exposure during the cleaning of the pump housing and impeller castings

different. These analyses indicate that the tools with the larger wheels cause more exposure than the smaller tools and that the greatest exposure occurred when the direction of the grinding swarf was directed back into the breathing zone.

Exhaust Air Recirculation

Overall particle penetration from the bench with intact filters was 56% for particles greater in size than about 0.5 µm (based on the factory calibration). For the bench with missing filters, the overall particle penetration was 113%. This increase in the number of particles may be caused by errors in measurement because simultaneous inlet and outlet measurements were not possible. The increase also may be caused by the release of dust that had settled into the outlet of the bench because the bench had been operating for only 5 min prior to the test. Results of the particle size distribution measurements are reported in Figure 3.

CONCLUSIONS

Overexposure to crystalline silica did not appear consistently throughout the cleaning department. The four samples exceeding the NIOSH REL for crystalline silica were on four different workers. Three of these four workers had another sample that was below the NIOSH REL. This suggests that some uncontrolled process variable (such as sand burn-in) or other casting differences such as size and shape may be responsible for exposure variability rather than individual work practices. The fraction of samples exceeding the NIOSH REL was similar to that identified in other studies of casting cleaning.[5–7] Thus, it may be inferred that the operations and silica exposures at this plant are typical of other ferrous foundries and the findings for this plant in regard to control measures could be applicable to other facilities.

In the cleaning of castings, silica exposure may be a function of the degree (although not easily quantifiable) of sand burn-in (and subsequent conversion to cristobalite) of the individual casting. The size of the casting may preclude working at a distance close enough to the grates of downdraft benches for efficient capture of the grinding dust, as the capture velocity drops off rapidly with distance above the grate. The real-time measurements indicated that the type of tool used, the direction of the grinding swarf, and the position of the tool (inside or outside of the casting) caused noticeable exposure differences. The 6-in. grinder and the 4-in. cutoff wheel, the largest grinders used, were the tools that contributed most heavily to dust exposure. Fortunately, designs for high-velocity, low-volume exhaust hoods are available for both of these tools.[10,19]

To minimize the hazard from sand burn-in, castings should be as clean as possible before grinding. The use of various mold surface coatings can reduce the amount of sand that is burned into the surface of the casting. Substitution of olivine sand has been shown to reduce the incidence of silicosis.[20] For conditions similar to those found in the foundry discussed herein, olivine could be substituted with little or no change in operations, as it is compatible with the alkyd-oil binder system that was used. This would involve increased cost of molding aggregate when compared to silica sand but may reduce dust control costs.

As is the case in many foundry cleaning rooms,[6] the exhaust from the downdraft tables was recirculated back into the foundry that was studied. Detailed recommendations for air recirculation and downdraft bench airflow requirements are contained in *Industrial Ventilation: A Manual of Recommended Practice*.[10] Measurements of dust removal efficiency indicated that an improperly maintained bench offered no protection and that even an apparently well-maintained bench removed less than half of respirable-sized dust particles. Therefore, the grinding benches in this plant could be redesigned by upgrading the filter efficiency to ensure the effective removal of dust particles from the exhaust air prior to recirculation or the exhaust air could be vented into a duct system discharging outdoors (according to federal, state, and local codes) through a central dust collection unit.

TABLE III. Ryan-Einot-Gabriel-Welsch (REGW) Multiple Range Test for Concentration/Activity Data[A]

REGW Group	*Log Mean*	*N*	*Combination[B]*
Casting: Pump Housing			
A	2.673	2	SOT
A	2.294	2	GOU
B A	2.080	3	GIU
B A	1.743	5	SOU
B A	1.682	58	SIU
B A	1.669	17	GOA
B A	1.612	18	GOT
B C	1.130	7	SIA
D C	0.597	22	SOA
D E	–0.119	35	GOD
E	–0.455	33	BIN
E	–0.617	94	NNN
Casting: Impeller			
A	1.816	6	GOT
B	–0.643	48	GOD
C	–1.024	75	CIN
D	–1.622	4	CIU
D	–1.847	43	NNN
D	–1.918	75	BIN
E	–2.267	54	SIN

[A]Means with the same letter are not significantly different.

[B]Key to combinations:

1st letter tool	2d letter grinding location	3d letter swarf direction
G: 6-in. grinder	I: inside casting	T: toward worker
S: 4-in. cutoff saw	O: outside casting	A: away from worker
C: cone grinder	N: other activity	D: down
B: burr grinder		U: up
N: other activity		N: undetermined or other activity

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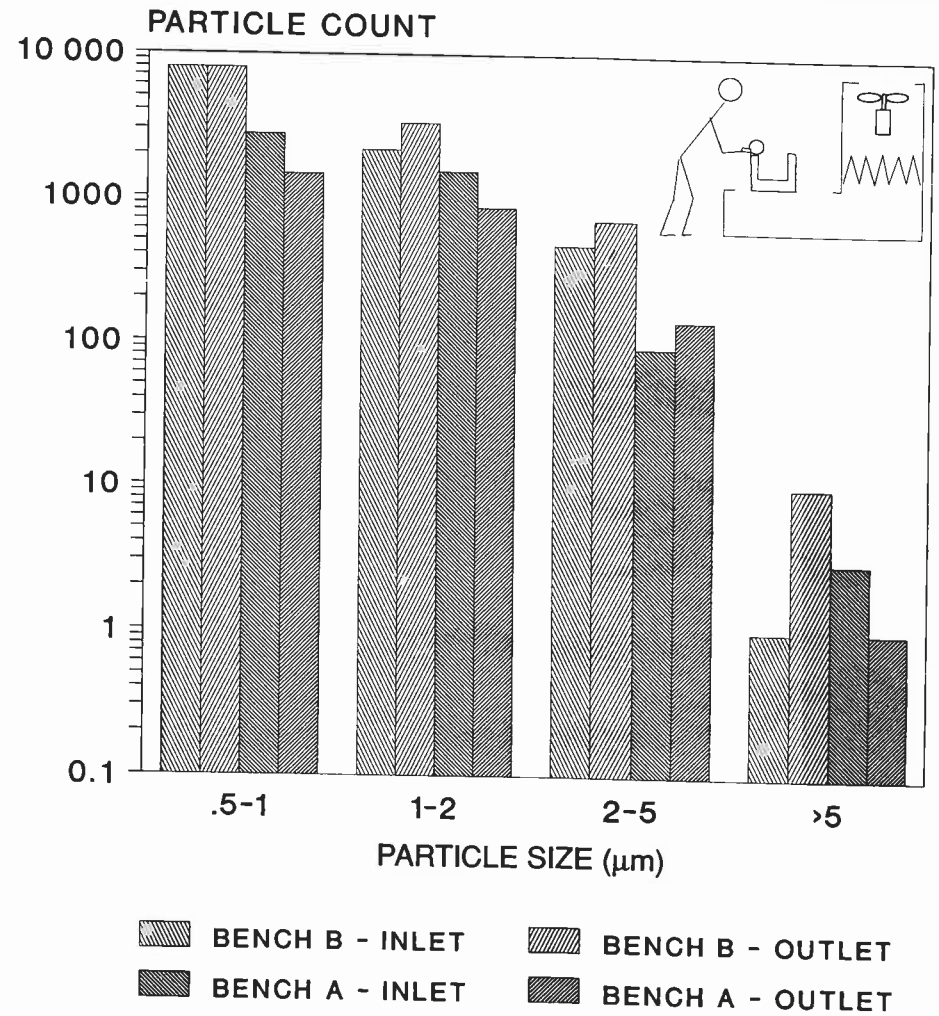

FIGURE 3. Particle size distributions from the downdraft grinding benches. Bench A had filters installed with no visible signs of leakage. Booth B had some secondary filters missing.

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An Examination of Occupational Medicine Practices

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The traditional occupational health on-site utilization of physicians as part of an overall occupational health program has been in decline in recent times. The on-site practitioner is increasingly being replaced by physicians who practice at an off-site location. The effects of this change on the health care delivered to the work force are largely unknown. By utilizing data from the 4490 facilities surveyed during the National Occupational Exposure Survey, it was possible to perform analyses of the association between the on- and off-site practice of medicine and several industrial facility characteristics and services usually associated with occupational medicine. Examination of the data indicated that, in comparison with on-site activity, the off-site practice of occupational medicine appears to result in diminished provision of the screening tests and medical examinations for which data were available.

The traditional delivery of health care services in the occupational setting involved the presence of a physician and/or other medical personnel in a special facility or health unit at the work site. However, corporate attitudes have been changing since the early 1970s, with management demonstrating increasing interest in preventive medicine, as shown in the rapid increase of health promotion activity[1,2] and in the discussions of incentive programs in health and safety.[3,4]

Simultaneously, the general practice of medicine in the United States has been shifting rapidly from the solo practitioner to the various forms of group practice, or medicine as a business.[5–8] The escalating costs of health care[9] and the resulting economic impact on corporate health care plans, coupled with the changes in corporate attitudes and medical practice, are having a profound effect on the delivery of health care related to employment.

An increasing proportion of the work force is being provided with some form of health care, but this work-related health care is more frequently being delivered off-site through contractual sources.[10] Particular emphasis on the provision of pre-employment physical examinations, possibly in conjunction with some form of drug testing, has received much recent attention in the popular press. (R. Rickles, *The Wall Street Journal*, January 3, 1989).

The effects of using off-site and/or contractual sources for work-related health care are largely unknown. Therefore, this study was undertaken to examine some of the procedural differences between the on- and off-site practice of occupational medicine.

Methods

The National Occupational Exposure Survey (NOES),[11–13] conducted by the National Institute for Occupational Safety and Health (NIOSH) from 1981 to 1983, was a cross-sectional survey of American industry intended to describe the health and safety characteristics of the workplace. The sampling frame for the NOES was generally defined as those industrial facilities in the private sector with eight or more workers covered under the Occupational Safety and Health Act of 1970.[14] The survey consisted of a probability sample of business facilities selected by a stratified, multistage sampling plan that considered geographical location, industry type by Standard Industrial Classification,[15] and number of employees per facility. The NOES consisted of 4490 site visits in 98 geographical areas, and each visit consisted of two parts: the administration of a standardized survey questionnaire to facility management, conducted in interview format by a NIOSH representative;

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0096-1736/90/3210-1037$02.00/0

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and a walk-through survey of the facility, which resulted in an inventory of the chemical, physical, and biological agents present in the work environment. Analysis of potential chemical and physical exposure data and the interaction between these variables and health care characteristics are the intended subjects of future research projects.

The data presented in this paper are derived from the management responses to the survey questionnaire, which contained 62 questions asked at each survey site. These questions were divided into four major sections: general facility information (nine questions), medical services (14 questions), industrial hygiene and safety practices (34 questions), and general recordkeeping (five questions). These responses were subjected to cross-tabulation and analysis in a NIOSH research project that involved the pairing of selected facility-specific management responses from the 4490 interviews conducted. For example, a response indicating that a physician was employed by a specific facility would be checked to determine whether that same facility also employed a nurse. The distribution of these two answers across the entire data base (positive or negative) was recorded, and the results were subjected to correlation analysis to determine whether the two events were dependent or independent, and to what degree. The results of this analysis were compared for different pairs and provided quantitative insight into the relationship between various occupational health and safety factors. For our study, this meant selecting those analyses which would give an assessment of various occupational medicine practices.

The analyses presented here result from the cross-tabulation and calculation of probability or correlation values for 42 paired responses from the medical services and general facility information sections of the survey management questionnaire. They were selected from the total of 1491 pairs analyzed during the cross-tabulation of the NOES management interview responses project (D. Pedersen, H. Venable, and W. Sieber, unpublished NIOSH report). The potential for further use by researchers interested in specific occupational health variables is quite extensive. Documentation of the research effort, including analyses performed and complete data files, is available on either a three-diskette set for PC utilization or in hard copy, upon written request to the authors.

Results

The results from this cross-tabulation effort are shown in Tables 1 and 2. It needs to be emphasized that, for the results presented here, the selected pairs that represented on-site physicians did not reflect whether they were corporate employees or contract physicians. Only the fact that they conducted their practices at the work site was considered. In contrast, off-site physicians were those with whom management had a contractual relationship and who provided their services at off-site locations or who would travel to the facility on an on-call basis. On-call physicians were regarded by the authors as off-site physicians because they are at a facility only upon specific request, and such intermittent visits were not, in the authors' opinion, equivalent to on-site practice. Those facilities observed to have both on- and off-site physicians were regarded as having on-site observations.

The data on screening tests, medical examinations, and recordkeeping are the result of determining whether industrial management had a policy of providing them on a periodic basis. Therefore, to the extent that physicians made an independent decision to provide screening tests or examinations, the data shown here are lacking. However, it is doubtful that a large amount of medical activity would take place without at least the tacit acceptance and/or encouragement of management, which would have resulted in an affirmative management response when the questionnaire was administered.

Finally, the authors observed that hospital industry data, almost without exception, reported the presence of physicians and/or nurses to provide occupational health care. This is in marked contrast to the observations in other industries. Accordingly, to eliminate a bias toward on-site physicians, hospital data were deleted from further consideration. This reduced the total number of facility observations from 4490 to 4261, of which 339 reported on-site physicians and 2517 reported contractual arrangements with off-site sources of physician services. The remaining 1405 facilities reported no formal medical arrangement.

The data in Table 1 are derived from the cross-tabulation project files. These percentages are calculated by dividing the number of desired outcomes by the total number of times the desired outcome was possible (eg, the number of times the presence of an on-site physician coincided with the provision of blood tests divided by the total number of on-site physicians observed).

These data indicate that facilities with on-site physicians are considerably more likely to provide all the medical services profiled than those using off-site physicians. The reader is cautioned that the data displayed for on-site physicians in small facilities are based on only 15 observations. We elected to display these data for comparison with off-site small plant data in spite of the limited number of observations because we believe that the incidence of on-site physicians in small plants is very low, and this is confirmed by the 324 observations in large plants out of the total 339 on-site observations. Nonetheless, great care should be used in interpreting the on-site small plant data.

This tendency for the provision of most occupational health care services to be associated more probably with the existence of an on-site physician has considerable significance in view of the recent decline in the industrial presence of on-site physicians[10,16–18] and the rapid growth of off-site occupational medical practice.[8,18,19]

The relatively high percentage of facilities with off-site physicians providing post-illness and pre-placement examinations, as well as recording health data on new

TABLE 1
Provision of Specific Medical Services by Type of Physician and Facility (Workplace) Employment Size

	On-Site Physician		Off-Site Physician	
	% Small* Facilities (n = 15)	% Large* Facilities (n = 324)	% Small* Facilities (n = 1411)	% Large* Facilities (n = 1106)
Ophthalmology	60.0	75.9	13.7	28.0
Audiometry	60.0	91.4	18.9	46.7
Blood tests	87.5	75.3	12.7	26.7
Urine tests	87.5	74.1	13.3	25.9
Pulmonary tests	87.5	75.3	11.0	25.6
Radiography examinations	87.5	73.5	10.1	23.9
Allergy tests	6.6	10.8	2.7	5.1
Immunizations	33.0	37.0	4.2	10.8
Pre-placement examinations	73.3	95.1	37.1	61.3
Record health data on new employees	80.0	97.5	63.0	81.4
Post-illness examinations	73.3	90.4	48.0	69.0
Employment termination examinations	6.6	25.0	0.8	4.1

* Small facilities employ fewer than 100 workers; large facilities employ 100 or more.

employees, lead us to speculate that the provision of episodic care[17] may be the predominant medical function of off-site medical contractors.

The data presented in Table 2 result from pairing the on- or off-site physician variables with numerical variables such as the age of the industrial facilities. This combination of discrete and continuous variables required a specific measure of correlation. The authors chose to utilize Goodman and Kruskal's γ measure of correlation.[20] These concordancy data are a measure of the relationship between the existence of a discrete variable (eg, physician type) and increasing values of the numeric variable. The higher the γ value, the greater the degree of association.

The data presented in Table 2 fall generally into two categories: those factors that are characteristically used to categorize industrial facilities (ie, age of plant, number of workers) and those factors that may be loosely descriptive of the level of occupational medicine effort in the workplace. In examining the categorization variables, it becomes obvious that the on-site practice of occupational medicine is far more highly correlated with older and larger industrial facilities than is off-site practice. It is generally acknowledged that there are probably more extensive resources available in such facilities.[1,2] which probably contributes heavily to the likelihood of the utilization of an on-site physician.

The data in Table 2 also imply that a smaller, newer plant is far more likely to rely upon off-site sources of health care, and demonstrate that male workers have a slightly higher association with the provision of physician services than do female workers. This effect may be simply a function of higher injury rates associated with those industrial activities (construction, manufacturing) that historically utilize a high proportion of male workers.[21]

The four factors displayed in the bottom half of Table 2 (number of physician hours per week, number of registered nurses, etc) are, we believe, descriptive of overall efforts in occupational medicine. In all four

TABLE 2
Probability of Concordance* between On- and Off-site Physicians and Selected Industry Facility Characteristics

	On-Site Physician	Off-Site Physician
No. y of facility operation	.566	.020
No. employees	.952	.208
No. male employees	.956	.356
No. female employees	.829	.241
No. physician h/wk	.985	.223
No. registered nurses	.978	.386
No. nurse/h/wk	.955	.082
No. y medical records kept	.477	.188

* Goodman and Kruskal's γ.[20]

cases, the highest concordances occur between these factors and the presence of an on-site physician. This would seem to indicate that increased levels of health care are associated with on-site physician practice. Given that there seems to be a relationship between plant size and availability of resources, as discussed above, it is no surprise that the number of physician hours per week provided to individual plants appears to be highly correlated with on-site provision. However, the considerably lower correlation between physician hours per week and off-site services implies that the level of physician services actually provided is lower in plants providing physician access through off-site sources regardless of employment size because the sample in this project spanned a representative sample of facilities by employment size. Estimates contained in an NOES publication[13] on the number of physician hours per 10 000 workers show a tendency toward a lower number of physician hours per worker in smaller plants. These smaller plants, as discussed earlier, are more inclined to use off-site physician services.

The high probability of concordance between the existence of an on-site physician and the number of employed registered nurses when compared with that for off-site operations would appear to be confirmation of

the historical tendency to provide a physician with support staff. Because on-site physicians are most likely to practice in large plants, it would stand to reason that the number of employed nurses necessary to provide services to a large employee population would be correspondingly high. The relatively low probability of correlation between off-site medical operations and the number of nurses employed is probably partially due to the preference of smaller plants to rely exclusively on contract medical services, although the use of nurse practitioners may be increasing in industry.[10,22] The number of nurse hours per week also correlates very highly with on-site practice, probably for much the same reasons. However, it should be noted that the management response to this inquiry specifically included the time received from nurses employed by off-site medical contractors. The low probability of correlation between off-site practice and the number of nurse hours may be partly due to a lack of management awareness of the nurse service that workers receive through medical contracts.

The data indicate that facilities with on-site physicians retain medical records longer than those with off-site physicians. This may be due to either differences between on- and off-site practice or discontinuity in recordkeeping operations as industrial facilities change off-site medical contractors. However, given the increasing role of contract medical care in industry, an important implication of this data is that retrospective studies of adverse health effects in the work force will become increasingly difficult, as retention periods decrease and recordkeeping becomes more fragmented.

Discussion

The differences in the amount of health care offered to the work force as a result of the physical location of the provider appear to be substantial. The analyses presented indicate that the provision of every individual screening test or health examination presented here is more highly associated with on-site than off-site access to the services of a physician. Whether the additional services provided are really necessary and result in an improved state of health for the work force cannot be determined from NOES data. However, if it is hypothesized that on-site physicians are more aware of the occupational factors that adversely affect the health of the work force because of their continuous presence in the workplace, then it could be argued that a profile of on-site occupational medicine practices represents a level of effort that is more likely to prevent illness. Based on this hypothesis, evidence of any decrease from on-site levels in the provision of medical services would imply that the health of the work force may be adversely affected.

The rapid growth of group medical practices[8,18,19] is a well-documented fact. Their potential role in occupational medicine is considerable and growing.[9,17] The decline of the on-site occupational physician referenced earlier, combined with the increasing role of the off-site group practice, appears to result in less health care provided to the work force.

Many of the discussions in the current literature regarding the differences between the traditional practice of medicine and the different types of group practices[17,23-26] note that although group practices deliver health care at reduced costs per individual employed,[27-29] they are criticized for being overly responsive to the economic pressures introduced by competition[6,7,18] and for lowering their costs by patient selection, scheduling routines, diminished referrals, and rationed use of technology.[7,28] This has resulted in such statements as "The most serious concern about HMOs is that doctors are ultimately faced with incentives to provide less care, rather than more" attributed to Kirk Johnson, General Counsel of the American Medical Association (B. Garcia, *The Wall Street Journal*, January 3, 1989). Several authors have raised the issue of medical ethics and the apparent conflict with the economic realities of for-profit medicine.[6,7,30,31]

On the other hand, the literature also contains studies that have compared the results of fee-for-service medical practice with those of various types of prepaid group practices,[25,27,28] and while finding real differences in the management of patients, concluded that there was no conclusive evidence that the health of the patient population suffered and that continuing study of the effects of the new medical care delivery systems on the health of the public is needed to determine whether there are real effects on the health of the consumer. Compounding the uncertainty surrounding the quality of care delivered by group practice medicine is the provision of occupational health care by physicians not specifically trained in occupational medicine. The minimal amount of exposure to occupational health in medical schools, and the national scarcity of Board-certified or eligible physicians[18,23,32] is believed to lead to a situation in which primary care physicians, who are untrained in occupational medicine and who do not practice medicine in the occupational environment, are delivering the majority of the health care provided to the American worker, and are doing so without any real knowledge of the accelerating complexity and diversity of the work environment.[33] It has been pointed out[2,34] that sporadic encounter with a working population is not conducive to the identification of those factors in the workplace that may be resulting in increased and unnecessary injury and illness.

The work presented here indicates that there is considerable difference in the occupational health care practices of the traditional on-site occupational medicine program and the emerging practice of off-site contractual health care. As discussed, the forces of economics are encouraging industry to utilize these off-site sources of health care for their workers and are forcing changes in the general practice of medicine and in the structure of the health care delivery system. The net effect of these changes on the health of the American work force is unknown. Identification of any changes in the health of the work force is complicated by the decline in traditional manufacturing and the rapid emergence

of the services sector,[35] which is typically composed of the relatively small, newer facilities that have been shown to be the most likely candidates for utilization of the off-site sources of health care. This imparts an additional urgency for further research into the effects of off-site occupational medicine and for the formulation of policies that would address the known weaknesses in the training and environmental knowledge of the physicians actually delivering occupational health care.

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Brief Report

Electromagnetic Field Exposure and Leukemia Mortality in the United States

Reports of excess leukemia mortality or morbidity among men employed in "electrical" occupations who have potential exposures to a wide variety of electromagnetic radiation, including 60 Hz fields, have been described for populations in Washington State 1950 to 1979,[1,2] California 1959 to 1961,[3,4] Wisconsin 1963 to 1978,[5] Massachusetts 1971 to 1973,[6] United Kingdom 1970 to 1973,[7] South East England 1961 to 1979,[8] and New Zealand 1979 to 1983.[9] A review article used a meta-analysis[10] to compare 11 epidemiologic reports and found a statistically significant summary relative risk of 1.2 for total leukemias for the 12 electrical occupations.

We noticed increased mortality for 10 of 11 similar electrical occupations during our analysis of recent mortality data from 14 US states (Table). Our summary proportionate mortality ratio (PMR) for total leukemias for the 11 occupations combined excluded the null value from the 95% confidence interval, as did three occupation-specific PMRs. Our analysis was performed on recently available industry-coded and occupation-coded mortality data from Georgia, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, and Wisconsin for one or more years from 1979 through 1985. (States provided the National Institute for Occupational Safety and Health (NIOSH) with coded death certificate data. Occupational coding was supported by the National Cancer Institute, NIOSH, and the National Center for Health Statistics.) Age-adjusted PMRs were examined by occupation and industry to detect increased mortality risks among 426 705 white men over age 15. A PMR is considered to be elevated if it exceeds 100. PMRs were characterized with test-based or approximate 95% confidence limits based on a Poisson distribution.[11]

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0096-1736/91/3302-0160$03.00/0

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The Table shows mortality for all leukemia and acute myelogenous leukemia for white men whose usual (lifetime) work was in one of the 11 occupations with potential exposure to electric or magnetic fields. PMRs were elevated for all leukemia for 10 of 11 occupations previously associated with excess leukemia.[10] A summary PMR for all leukemia for the 11 occupations, computed by totaling expected and observed deaths, was 119. The 95% confidence limits were 102 and 137. Although the lower confidence limit was just above the null value and the 19% elevation in leukemia was modest in absolute value, our summary PMR was very similar to the summary relative risk across all studies and all jobs reported by Savitz et al.[10] The three highest PMRs for all leukemia (telephone linemen, installers, and repairmen; telegraph and telephone operators; and photographic equipment manufacturing) showed excess risks that were consistently elevated for both all leukemia and acute myelogenous leukemia. The PMR for photographic equipment manufacturing was the only one of the ten elevated PMRs for all leukemia to exclude the null value from the 95% confidence interval. (PMR = 157, 24 observed deaths, 95% CI = 103–230.) The highest PMRs were not based on broad industrial classifications but on relatively specific occupational titles.

When only mortality due to acute myelogenous leukemia was considered, all three highest PMRs increased, based on small numbers of deaths. As the Table shows, the PMR for telegraph, telephone, and other communications equipment operators was highest (PMR = 499, 3 deaths observed) and the lower 95% confidence limit excluded the null (95% CI = 127-1361). The PMR for telephone linemen, installers, and repairmen was 347 for acute myelogenous leukemia, based on two deaths, but the lower confidence limit did not exclude the null (Table). The PMR for photographic equipment manufacturing (includes movie projection equipment) increased to 213, based on 11 deaths, and the 95% confidence interval excluded the null (95% CI = 111-368) (Table).

A recent survey[12] reported having measured the extremely low frequency (below 100 Hz) electric and magnetic field exposures of workers in some of the "electrical" occupations that have elevated leukemia rates and, for comparison, in residences. Based on this

TABLE
Mortality from Leukemias among White Men in Electrical Occupations in 14 US States,* 1979–1985

Occupations/EM†/IOC‡	Mortality from all Leukemias (204–8§)			Mortality from Acute Myelogenous Leukemia (205§)		
	PMR‖	Obs¶	95% CI#	PMR‖	Obs¶	95% CI#
Telephone linemen, installers and repairmen/EM/527	210	4	(67-508)	347	2	(60-1180)
Telegraph, telephone, and other communications equipment operators/306, 348–53	194	4	(61-459)	499	3	(127-1361)
Photographic (includes movie projection) equipment mfg/M/380	157	24	(103-230)	213	11	(111-368)
Aluminum workers/272	136	11	(71-236)	—	1	—
Stationary (power plant) engineers/EM/696	135	27	(91-194)	67	4	(21-161)
Electrical, electronic engineers/M/055	128	19	(80-197)	132	6	(54-277)
Telephone installers, repairers/529	125	8	(58-237)	—	0	—
Electrical equipment assemblers/M/683	124	2	(21-413)	—	0	—
Locomotive operating occupations/824	114	12	(62-194)	100	3	—
Electric, gas utilities workers/460	109	45	(80-144)	122	15	(71-197)
Welders, flame cutters/M/783	84	27	(57-121)	60	6	(24-125)
Totals	**119**	**183**	**(102-137)**	**114**	**51**	**(85-150)**

* The 14 states include Georgia, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, and Wisconsin.

† Indicated extremely low frequency (below 100 Hz) magnetic (M) or electric (E) field exposures reported in Bowman JD, Garabrant DH, Sobel E, Peters JM. Exposures to extremely low frequency (ELF) electromagnetic fields in occupations with elevated leukemia rates. *Appl Ind Hyg.* 1988;3:189–194.

‡ Industry and Occupation Codes (IOC) from the US Bureau of Census. *1980 Census of Population. Alphabetical Index of Industries and Occupation.* Final ed. US Dept of Commerce, Bureau of the Census; 1981. (Publication PHC-80-R3).

§ *International Classification of Diseases.* 10th rev. Geneva: World Health Organization; 1978.

‖ Proportionate Mortality Ratio (observed/expected mortality ×100) was based on the proportionate mortality of 14 states' white men adjusted for age; PMRs were not calculated if number observed was less than 2.

¶ Obs, observed.

95% confidence intervals were calculated for PMRs based on a Poisson distribution. Rothman KV, Boice JD Jr. *Epidemiologic Analysis with a Programmable Calculator.* NIH Publication No. 79-1649. Washington, DC: US Government Printing Office; 1979.

report, the symbols E and M on the Table indicate occupations found to have exposures significantly above the 95th percentile of residential exposures.[12] As the Table shows, 6 of our 11 "electrical occupation" categories when measured[12] were found to have magnetic and/or electric field exposures.

We interpret our findings to be generally consistent with those reported previously and as a confirmation that occupational exposure in electrical occupations may be associated with enhanced leukemia risk. Particularly notable is the consistency across several studies of the elevated risk for telegraph, telephone, and related communications equipment operators and for telephone linemen and installers.

Although the exact cause of the leukemia excess is not clear, the occupations grouped as sharing exposures to electric and magnetic fields also may involve potential exposure to suspected leukemogenic chemicals, including pesticides, creosol, zinc chromate, coal tar pitch volatiles, polychlorinated biphenyls, polynuclear aromatics, and formaldehyde.

The job titles and classifications shown in the Table indicate the possible occupational exposures of "electrical occupations" but do not imply a causative link with increased leukemia mortality. Although electromagnetic field exposure cannot be definitely identified as a causative agent, some aspect of electrical occupations may be associated with increased mortality risk for the workers in the occupations that should be investigated. Recent cellular level studies of electromagnetic fields have suggested that the fields may act as promotors rather than initiators of cancer.[13]

Limitations of the proportionate mortality methods include the random misclassification of retrospective exposure status and/or cause of death as reported on the death certificate. These limitations may result in biased estimates of risk, usually expressed as lowered PMRs.

The analytical investigations under way throughout the world should be pursued aggressively.

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Acknowledgments

The authors gratefully acknowledge encouragement from D. Garabrant and helpful comments from D. Savitz, W. Murray, and F. Stern.

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Occupational Exposures and the Mortality Patterns of US Construction Trades Workers, 1984–1986: Filling in the Gaps. C. Robinson,* H. Venable, F. Stern, C. Burnett, K. Sieber, J. Sestito, T. Frazier, and M. Fingerhut (NIOSH, Cincinnati, OH 45226).

Construction is one of the largest industries in the United States, with 7.6 million workers employed, many of whom are in the special construction trades. Evidence suggests that construction special trades workers experience a high proportion of work-related injuries, but not much is known about health. This has led to an effort to explore the health problems of construction workers. As a first step, the authors analyzed National Institute for Occupational Safety and Health (NIOSH) special data sets that described the potential environmental exposures and mortality experience of construction workers during the last decade. The 1984–1986 NIOSH occupational mortality surveillance data were analyzed for the proportionate mortality ratio (PMR) patterns of construction workers in special trades. These data were pooled from 19 US states that, along with the National Center for Health Statistics and the National Cancer Institute, have shared the added costs of coding occupation and industry on their death certificates. Results show that several site-specific cancers and other chronic disease PMRs were statistically significantly elevated for 61,682 white male construction workers. Men younger than age 65 years, who were probably still employed at death, had significantly elevated PMRs for cancer, asbestos-related diseases, mental disorders, alcoholism, digestive diseases, falls, poisonings, industrial fatalities, and homicides. Statistically significant elevated PMRs were observed for men in several construction trades. Environmental data indicated that there were many potentially hazardous exposures at construction worksites. The data suggest several hypotheses for future in-depth research.

AMERICAN JOURNAL OF Public Health reprint

Public Health Briefs

Surveillance of Occupational Lung Disease: Comparison of Hospital Discharge Data to Physician Reporting

KENNETH D. ROSENMAN, MD, LINDA TRIMBATH, AND MARTHA STANBURY, MPH

Abstract: A survey of 762 New Jersey physicians showed that 35% reported seeing patients with either asbestosis, coal worker's pneumoconiosis, occupational asthma or silicosis. Three to four times as many patients with these diagnoses were seen as outpatients as were hospitalized. The implications of these results in using hospital discharge data for occupational disease surveillance are discussed. (*Am J Public Health* 1990; 80:1257–1258.)

Introduction

It has been proposed that hospital discharge data be used as part of an occupational disease surveillance system.[1,2] One of the limitations of hospital discharge data is the lack of information on non-hospitalized individuals. We conducted a survey of physicians in New Jersey to obtain estimates of how many patients they saw in their practice with asbestosis, coal workers' pneumoconiosis, occupational asthma, or silicosis in comparison to the number of patients they admitted to the hospital with the same diagnosis.

Methods

The names and addresses of physicians were obtained either from the state hospital discharge system or directly from the hospitals under state occupational disease reporting regulations (New Jersey Administration Code 8:57–1.13). Names and addresses of physicians were obtained by linking medical license numbers in the hospital discharge record to a data set of all licensed physicians in the state. The physicians surveyed had discharged at least one patient for the year 1985, 1986 or 1987 from one of New Jersey's 105 acute care (non-federal) hospitals with the diagnosis of asbestosis (ICD 501), coal workers' pneumoconiosis (ICD 500), pneumoconiosis due to other inorganic dust (ICD 503), pneumonopathy due to inhalation of other dust (ICD 504), pneumoconiosis unspecified (ICD 505), silicosis (ICD 502).

In the spring of 1988, a letter was mailed to these physicians requesting information about their medical specialty, an estimate of the total number of their patients newly diagnosed with asbestosis, coal workers' pneumoconiosis, occupational asthma, and silicosis in the calendar year 1987, and an estimate of the proportion of these patients admitted to the hospital during that same year. Non-respondents to a second and third mailing were contacted by telephone.

Results

A total of 847 physicians were included in the survey, of whom 762 (90.0 percent) completed the questionnaire. The reasons for non-response were: 29 (3.4 percent) letters were undeliverable; 20 (2.4 percent) refused to participate when telephoned; 11 (1.3 percent) were unreachable despite five telephone calls; nine (1.1 percent) had unlisted telephone numbers; six (.7 percent) retired; five (.6 percent) moved out of state; five (.6 percent) were deceased.

Table 1 shows the number of respondents, by medical specialty, who saw patients in 1987 with any of the lung conditions under consideration. The percentage of physicians reporting patients in 1987 is less than 100 percent, because many physicians may have had no patients with these diagnoses in 1987 or because they did not report all such patients.

Table 2 shows the proportion of patients hospitalized: for asbestosis 34 percent (95% CI = 31, 37); for coal workers' pneumoconiosis 26 percent (95% CI = 18, 35); for occupational asthma 23 percent (95% CI = 19, 27); for silicosis 27 percent (95% CI = 20, 35) were hospitalized. For all diseases combined, 548 (30 percent) of 1,814 patients (95% CI = 28, 32) were hospitalized.

Discussion

For the four diseases surveyed, physicians stated that for every patient hospitalized with the condition they had two to three additional patients with the same diagnosis who had not been hospitalized. This selected group of physicians reported nearly as many newly diagnosed cases of pneumoconiosis in New Jersey as are reported annually in the supplementary data system of the Bureau of Labor Statistics.[4] The number of additional patients not hospitalized varied both by disease as well as by the specialty of the reporting physician. The variation of hospitalization by specialty may be a reflection of the severity of disease seen by different physicians. For example, surgeons reported that 79 percent of their patients with asbestosis were hospitalized. The variation, however, may also reflect the relative amount of time physicians see hospitalized versus ambulatory patients.

None of the physicians reported their specialty as occupational medicine. Hospitalizations were not limited to a few specialty groups such as pulmonary physicians. Percentages of physicians reporting patients with lung conditions in 1987 by specialty varied from 8–79 percent although all physicians had admitted patients with these lung conditions

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TABLE 1—Total Number of Physicians Responding and Percent by Specialty who Reported Patients for the year 1987 with Either Asbestosis, Coal Workers' Pneumoconiosis, Occupational Asthma, or Silicosis

Medical Specialty	Number Physicians Responding	Percent Physicians Reporting Patients with Any of the Lung Conditions	Percent Physicians Reporting Asbestosis	Percent Physicians Reporting Silicosis	Percent Physicians Reporting Coal Workers' Pneumoconiosis	Percent Physicians Reporting Occupational Asthma
Internal Medicine	205	43.9	33.2	8.8	6.3	18.5
Pulmonary	65	78.5	70.8	29.2	30.8	61.5
Family/General Medicine	106	41.5	30.2	7.5	9.4	20.9
Surgery	110	17.3	16.4	3.6	0.9	2.7
Cardiology	80	35.0	31.3	3.8	6.3	10.0
Urology	49	8.2	8.2	0.0	0.0	0.0
All Other Specialties	126	18.3	14.3	1.6	4.0	16.7
No Specialty	21	19.0	14.3	4.8	0.0	4.8
Total	762	34.5	28.1	7.2	7.1	17.6

TABLE 2—Numbers of Reported Patients and Percent Hospitalized in 1987 with each Occupational Lung Disease by Physician Specialty

	Asbestosis		Silicosis		CWP		Occup Asthma		All Lung Diseases	
Physician Specialty	No. pts	% hosp	No. pts	% hosp	No. pts	% hosp	No. pts	% hosp	No. pts	% hosp
Internal Medicine	162	45	33	46	27	37	138	24	360	36
Pulmonary	592	17	66	26	46	15	188	20	892	19
Fam/Gen Medicine	78	32	15	7	11	36	61	13	165	23
Surgery	77	79	15	0	1	0	16	19	109	59
Cardiology	140	61	16	4	12	25	21	62	189	57
Urology	5	20	0	—	0	—	0	—	5	20
All other specialties	53	55	4	25	6	50	21	29	84	46
No specialty given	8	25	1	0	0	—	1	0	10	20
Total	1115	34	150	27	103	26	446	23	1814	30

in 1985, 1986 or 1987. Efforts are underway to follow up this survey by encouraging the physicians to report the names of patients they estimated on the questionnaire. Similar surveys in other states will be useful to examine if there are differences in care patterns in different states.

The physicians response rate to the questionnaire was excellent. We attribute this to its briefness and to our only asking for estimates. This is also its major limitation as we did not evaluate the accuracy of the physicians estimates. According to statewide hospital discharge data for 1986, there were 881 patients discharged with asbestosis, 97 patients with silicosis, and 235 patients with coal workers' pneumoconiosis. For the first two diagnoses, the hospital discharges were less than those reported by the physicians; for coal workers' pneumoconiosis, the hospital discharges were more than those reported by physicians. No data on occupational asthma is available from discharge data.

If the percentages of underreporting of 67 to 75 percent for different diseases found in this survey is generalizable and reassessed by periodic surveys of physicians then hospital discharge data because of its relative ease of collection and low cost would be a useful method to examine trends and estimate the number of occupational pneumoconioses.

Recently, the National Institute for Occupational Safety and Health (NIOSH) has been promoting the concept of sentinel provider-based occupational disease surveillance systems.[3] This survey shows that hospital discharge data can be used directly or indirectly to identify names, addresses and medical specialties of potential sentinel providers, and that, with sufficient follow-up, these physicians are willing to report to a state health department information that can be relied on for occupational disease surveillance.

ACKNOWLEDGMENTS

We wish to thank all the physicians who took the time to respond to our questionnaire. We wish to acknowledge the assistance of Gwendolyn Solice-Sample and Ruth VanderWaals. This activity was funded under a National Intitute of Occupational Safety and Health Cooperative agreement.

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American Journal of Industrial Medicine 20:163–174 (1991)

Development, Use, and Availability of a Job Exposure Matrix Based on National Occupational Hazard Survey Data

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A job exposure matrix has been developed based on potential exposure data collected during the 1972–1974 National Occupational Hazard Survey (NOHS). The survey sample was representative of all U.S. non-agricultural businesses covered under the Occupational Safety and Health Act of 1970 and employing eight or more employees. Potential worker exposure to all chemical, physical, or biological agents was recorded during the field survey if certain minimum guidelines for exposure were met. The job exposure matrix (JEM) itself is a computerized database that assists the user in determining potential chemical or physical exposures in occupational settings. We describe the structure and possible uses of the job exposure matrix. In one example, potential occupational exposures to elemental lead were grouped by industry and occupation. In a second example, the matrix was used to determine exposure classifications in a hypothetical case-control study. Present availability as well as future enhancements of the job exposure matrix are described.

Key words: occupational exposures, surveillance, industry, occupation, National Occupational Hazard Survey, lead, case-control study

INTRODUCTION

In studying occupational health, a knowledge of occupation-specific exposures is useful since exposures to many potentially hazardous substances may occur in the workplace at high concentrations. Because exposures vary for occupations and industries, several approaches have been used to identify occupation-specific exposure information. Direct quantitative exposure measurements, if they are available, are useful to determine exposure categories for analytic field studies. However, many studies of mortality or morbidity are conducted by using vital statistics or other record systems where the only exposure data recorded are the decedent's or respondent's occupation or industry. For analysis of these studies, a classification system linking industry, occupation, and exposure would be useful. A job exposure matrix (JEM) is such a classification system linking occupational titles with occupational exposures.

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Accepted for publication November 26, 1990.

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JEMs have been used to identify industries or occupations in which exposure to given chemical or physical agents might occur.

Different approaches have been used to develop JEMs, depending on the sources of exposure data and intended usage of the JEM. JEMs have been constructed by using job titles, employee interviews, and company records for individual plants or industries [Gamble et al., 1976; Kaupinnen et al., 1986; Kaupinnen and Partanen, 1988]. Such matrices may be extensive and include quantitative exposure measurements. They are specific to industries for which they were constructed. More general JEMs covering a range of industries have also been developed in which exposure agents and indices of exposure in individual occupations were determined from the literature or by a panel composed of chemists and industrial hygienists [Hoar et al., 1980; Olsen et al., 1986; Pannett et al., 1985; Vineis and Magnani, 1985]. Substances included in these JEMs are limited to those described in the literature or known to the panel. Another approach, the assignment of individual exposures by a team of chemists and industrial hygienists following an in-depth interview of subjects, has been followed in a large case-control study in Montreal, Canada [Siemiatycki, 1984, 1988; Gerin, 1988].

A JEM has been developed by researchers at the National Institute for Occupational Safety and Health (NIOSH). This JEM, hereafter referred to as the JEM or NOHS-based JEM, is based on potential occupational exposure data recorded during the National Occupational Hazard Survey (NOHS), a national survey of businesses representative of U.S. industry. In this article, the development, structure, content, and possible uses of the NOHS-based JEM are described. Examples are included of a few uses of the JEM. Availability of the JEM and future enhancements are also described.

MATERIALS AND METHODS

The National Occupational Hazard Survey

The 1972–1974 National Occupational Hazard Survey (NOHS) [NIOSH, 1974, 1977, 1978] was a 2 year field survey conducted by NIOSH. It was intended to describe the health and safety conditions in the American workplace and to determine the extent of workers' exposure to chemical, physical, and biological agents. Data on potential exposures to all hazardous agents observed in the workplace were collected during the NOHS site visits for a sample of industries. The survey sample was representative of all non-agricultural businesses that were covered under the Occupational Safety and Health Act of 1970 and employed eight or more employees. Businesses with less than eight employees were considered to be too numerous and transient to survey accurately.

The NOHS sample consisted of 4,636 facilities in 67 metropolitan areas of the United States. The selection scheme was a two-stage process involving stratification and systematic selection procedures [NIOSH, 1974, 1977, 1978; Sieber, 1985]. The number of employees, Standard Industrial Classification (SIC), and geographical location of each facility were important characteristics in the selection process. The number of facilities surveyed and average number of employees per facility are shown by size category, i.e., number of employees, in Table I.

TABLE I. Number of Facilities Surveyed and Average Number of Employees by Facility Size and Industrial Category (1972–1974 NOHS)

Industrial category	SIC range	Total no. of facilities surveyed	Facility size (no. of employees)	Percent of facilities observed in size category	Average no. of employees in size category
Agriculture, forestry, fishing	07–09	47	8–99	94	22
			100–249	6	212
			250+	0	0
Oil & gas extraction	13	32	8–99	63	36
			100–249	28	200
			250+	9	667
Construction	15–17	503	8–99	82	30
			100–249	17	173
			250+	1	665
Manufacturing	19–39	2,751	8–99	57	39
			100–249	34	223
			250+	8	1,735
Transportation, communcation, electric, gas, and sanitary services	40–49	308	8–99	62	36
			100–249	29	218
			250+	9	2,356
Wholesale, retail trade	50–59	506	8–99	83	27
			100–249	15	194
			250+	2	1,482
Finance, insurance real estate	60–67	144	8–99	77	29
			100–249	21	198
			250+	2	1,797
Services	70–89	345	8–99	76	30
			100–249	17	187
			250+	7	954
Total		4,636	8–99	66	34
			100–249	28	215
			250+	6	1,694

Data Collection

Data for the NOHS were collected by 20 surveyors, all recent engineering graduates specifically trained for the NOHS. Training of the surveyors included completion of a 9 week course in industrial hygiene, 3 weeks of field training in survey and investigation techniques with state industrial hygienists, and completion of a trial field inspection using the official NOHS field manuals and recording forms.

Potential exposure information was collected during a walk-through inspection of each facility. Potential exposure to any agent was recorded if the following guidelines were met:

1. a chemical, physical, or tradenamed product must have been observed in sufficient proximity to an employee that one or more physical phases of the agent were

likely, in the judgment of the surveyor, to enter or contact the body of the employee; and

2. the potential exposure must have met minimum duration guidelines, i.e., it must have presented a potential exposure for at least 30 minutes per week (on an annual average) or at least once per week for 90% of the weeks of the work year.

Data on the presence of engineering controls over potential exposure and duration of potential exposure in each facility were recorded. Duration of potential exposure was defined as full-time (if potential exposure time was greater than 4 hours per day on a daily basis of at least 90% of the company's work year) or part-time.

Potential exposures recorded during the survey were classified into two categories: tradename or actual exposures. If the surveyors were able to observe and identify a specific exposure agent during the survey, it was called an "actual exposure." In cases where an exposure agent occurred as a formulated product labeled with a brand name, the ingredients were later identified; these were called "tradename exposures." Roughly 70% of the data collected in the NOHS was associated with tradename products and component ingredients were determined for 85% of these tradename products.

Data on 8,342 different potential exposure agents observed in facilities representing 639 SIC codes and 442 occupations were included in the NOHS. Facility activity was coded by four-digit 1967 SIC code [OMB, 1972], occupation by 1970 Bureau of the Census occupation codes [Bureau of The Census, 1970], and agent by a unique five-digit hazard code assigned at NIOSH. Unique hazard codes were developed by NIOSH because many agents were observed during the NOHS that had not been assigned codes by other conventions such as a Chemical Abstracts (CAS) number or a Registry of Toxic Effects of Chemical Substances (RTECS) number. Cross-referencing of hazard codes to Chemical Abstracts and Registry of Toxic Effects of Chemical Substances numbers has been completed. All data were coded into machine-readable format and stored on magnetic tape for use with an IBM 3090 model 400 computer system.

National estimates of the number of employees in each industry surveyed in the NOHS were calculated by using payroll information and ratio estimation techniques [NIOSH, 1974, 1977, 1978; Sieber, 1985].

Development and Structure of the NOHS-Based Job Exposure Matrix

The NOHS-based job exposure matrix is a three-level classification system in which potential worker exposure information collected during the National Occupational Hazard Survey (NOHS) walk-through inspection is classified by industry and occupation [Sieber, 1990]. Each level of classification is nested within the previous one. The three levels of classification in the JEM are thus industry, occupation within industry, and potential exposure within occupation within industry. The nested structure is important for flexibility in the use of the JEM since the maximum data may be included at each level of classification, and data may be easily obtained at each level of classification.

In order to arrange potential exposure data from the NOHS in a form that could be easily retrieved from the JEM, certain simplifications of the data were made for presentation in the JEM. The physical form of the agent, type of engineering control, and whether or not the control measure was functioning were not indicated in the JEM. Including this data would have greatly increased the size and computer storage

TABLE II. Data Included at Each Classification Level in the NOHS-Based JEM Level

Industry	Industry and occupation	Potential exposure
Industry code[a]	Industry code[a] Occupation code[b]	Industry code[a] Occupation code[b] Hazard code CAS number[c] RTECS number[c]
No. of facilities surveyed within SIC	No. of facilities surveyed where this SIC-occupation group was observed	No. of facilities in SIC-occupation group where agent was observed
No. of employees observed within SIC	No. of employees observed in SIC-occupation group	No. of employees observed to be potentially exposed to agent in SIC-occupation group
Estimate of total no. of employees in SIC	Estimate of total no. of employees in SIC-occupation group	Estimate of total no. of employees potentially exposed to agent in SIC-occupation group No. of employees potentially exposed full time to agent in SIC-occupation group No. of employees with actual exposure to agent in SIC-occupation group No. of employees in SIC-occupation group working in facilities with no form of control over potential agent exposure

[a]Available using either SIC or Bureau of the Census codes.
[b]Bureau of the Census occupation codes.
[c]If available.

requirements for the JEM. Such information is available on request from the authors, however. Potential exposures to substances whose individual product formulations could not be resolved were also excluded from the JEM in order to present only data based on known product formulations.

The organization of occupational information from the NOHS walk-throughs into the job exposure matrix format followed a series of steps. First, potential data to be included in the JEM were selected. Next, three computer files, each including data specific to one classification level in the JEM, were created. One file included data for the industry as a whole, one for each occupation observed in the industry, and one for each potential exposure agent observed in each occupation in the industry. The three files were merged to form the JEM. All information at each step in the processing sequence was categorized by the size of the facility in which the observations were made (small, 8–99 employees; medium, 100–499 employees; large, over 500 employees).

Data included at each classification level in the JEM are shown in Table II. Data at each level of classification are unique to that level. Data on industrial employment, for example, are found at the industry level, on employment in an industry/occupation

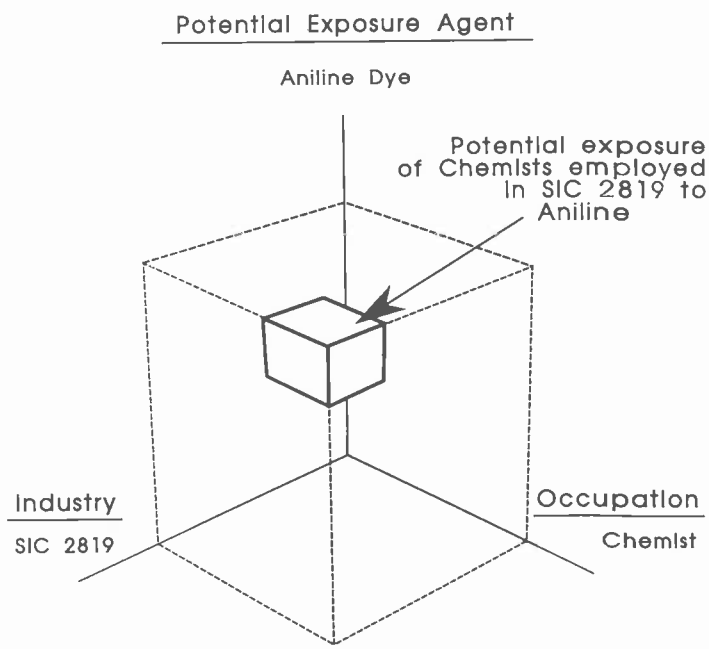

Fig. 1. Representation of the JEM for data retrieval.

grouping are at the industry/occupation level, and on number of employees potentially exposed to the agent in the industry/occupation group are at the potential exposure level. Percentages of employees potentially exposed to an agent in an industry or industry/occupation group may be found by using this scheme.

The JEM may be thought of as a three-dimensional array with axes for each level of classification as shown in Figure 1. In Figure 1, information on all agents to which chemists employed in SIC 2819 (Manufacture of Industrial Inorganic Chemicals, N.E.C.) were observed to be potentially exposed may be obtained at the intersection of the industry and occupation axes. Information on potential exposure of chemists employed in SIC 2819 to aniline may be obtained from the cell at the intersection of the industry, occupation, and potential exposure axes. Occupations or industries in which employees may be potentially exposed to aniline dye may be found from the intersections of the occupation or industry axes, respectively, with the potential exposure axis.

USE OF THE NOHS-BASED JEM

The JEM may be used to associate potential exposure with specific occupational settings as illustrated in the following two examples. The first example illustrates the use of the NOHS-based JEM to list the occupational settings where potential worker exposure to elemental lead was recorded. The second example illustrates the use of the NOHS-based JEM with vital statistics data to objectively determine exposure classifications by using usual occupation and industry of employment.

TABLE III. Industry/Occupation Groups Where 50 or More Employees Were Observed to Have Potential Exposure to Metallic Lead (NOHS-Based JEM)

Industry	Occupation	No. of employees observed in industry/ occupation group	Percent of employees potentially exposed to metallic lead
Water transportation	Industrial machinery repairers	141	56.7
Radio, TV, and communication equipment	Tool and die makers	215	46.5
Miscellaneous nonmetallic mineral and stone products	Industrial machinery repairers	161	34.2
Ship- and boat-building and repairing	Machinist	671	30.8
Telephone communications	Telephone line installers and repairmen	835	28.6
Ship- and boat-building and repairing	Plumbers, pipefitters, and steamfitters	428	25.7
Blast furnaces, steelwork, rolling and finishing mills	Construction laborers	276	19.2
Machinery, except electrical, N.E.C.	Laborers, except construction	369	15.7
Newspaper publishing and printing	Typesetters and compositors	618	14.6
Blast furnaces, steelworks, rolling finishing mills	Plumbers, pipefitters, and steamfitters	560	9.5
Machinery, except electrical, N.E.C.	Assemblers	2,056	5.4
Construction	Plumbers, pipefitters, and steamfitters	1,520	3.3
Radio, TV, and communication equipment	Electrical and electronic equipment assemblers	3,739	1.6

Profiling Potential Exposures to a Single Agent: Elemental Lead

The use of 59 different lead compounds in 98 different industries was listed in the JEM. For this example, only the use of elemental lead was considered.

Potential exposure to elemental lead was observed in 66 occupations across 59 industries. A total of 3,280 employees were observed to be potentially exposed to elemental lead. Those industry/occupation groups where 50 or more employees were observed in the NOHS to be potentially exposed to metallic lead are shown in Table III. The number observed and percent of employees potentially exposed in the respective industry-occupation groups are also shown in Table III; 57% of industrial machinery repairers observed in the water transportation industry were observed to be potentially exposed to elemental lead, while just 1.6% of electrical equipment assemblers observed in the radio, TV, and communication equipment industry were potentially exposed to elemental lead.

TABLE IV. Age-Adjusted Odds Ratios for Leukemia Deaths With Potential Exposure to Ionizing Radiation Determined by the NOHS-Based JEM

Exposure category	Age at death	Cases		Controls		Odds ratio	95% confidence interval
		Exposed	Total	Exposed	Total		
By industry	all	56	368	716	4,317	.9	(.7, 1.2)
	<65	27	155	324	1,555	.8	(.5, 1.2)
	64+	29	213	392	2,762	1.0	(.6, 1.4)
By occupation Within industry	all	13	368	115	4,317	1.3	(.7, 2.3)
	<65	9	155	56	1,555	1.7	(.8, 3.4)
	64+	4	213	59	2,762	.9	(.3, 2.4)

Determining Exposure Classifications for Epidemiologic Studies

Potential exposure data obtained from the NOHS-based JEM may be used as an objective measure of exposure in epidemiological studies [Preston-Martin et al., 1989; Brackbill et al., 1990]. Exposure to ionizing radiation has been associated with the development of leukemia [Court Brown and Doll, 1965; Matanoski et al., 1975; Rutstein et al., 1983]. The use of the NOHS-based JEM to determine exposure classifications objectively will be illustrated in a hypothetical case-control study of the association of potential exposure to ionizing radiation and leukemia or aplastic anemia.

Cases and controls were selected from 1968–1978 Rhode Island death certificates [Kelley and Gute, 1986]. All deaths from leukemia were defined as cases for the analysis. A 10% random sample of all non-case deaths was drawn for the controls.

Industries and occupations where potential exposure to ionizing radiation was observed were objectively identified by using the JEM. All cases and controls whose death certificates listed an industry and/or occupation with potential for exposure to ionizing radiation according to the JEM were considered to be exposed. All other occupational groups were considered to have no exposure. Age-adjusted odds ratios were calculated by using the Mantel-Haenszel method [Schlesselman, 1982; Rothman and Boice, 1979]. Fisher's exact test was used for probability testing when expected cell sizes were smaller than five. The analysis was performed first by using potential exposure in industry as the grouping variable, and then repeated by using exposure within the industry-occupation pair as the grouping variable.

Results for this analysis are shown in Table IV. Therein, odds ratios appear to be greater when classification is by potential exposure in an industry-occupation group, rather than by potential exposure in the industry alone. The analysis is intended as an example of exposure groupings possible by using the NOHS-based JEM.

ADVANTAGES AND LIMITATIONS OF THE NOHS-BASED JEM

The examples presented are intended to illustrate the use of the NOHS-based JEM in the identification of potential exposures associated with specific industries and/or occupations. Potential exposure information in the JEM was collected primarily from a sample of manufacturing facilities employing 8–99 employees (see Table I). The use of the JEM in studies of industries that are similar to those included in the JEM sample should offer several advantages in analysis. One advantage might be a reduction in cost. Rather than obtaining estimates of exposure by methods such as

interviews or from a panel, such information could be obtained through application of the JEM. Other variables included in the JEM which might be used as surrogate exposure data are full- or part-time exposure to the agent and the estimated proportion of employees observed to be potentially exposed to the agent.

One use of a JEM in epidemiologic studies has been to classify employees by hazardous exposure in order to study the association between occupational disease and exposure [Coggon et al., 1984; Gamble et al., 1976; Hoar et al., 1980; Hinds et al., 1985; Linet et al., 1987; Sieber et al., 1986; Spitz and Johnson, 1985; Siemiatycki et al., 1987; Wilkins and Sinks, 1984]. The potential for misclassification of exposure in JEMs has caused some researchers to question their value. Such misclassifications would tend to bias any association toward the null value [Kaupinnen and Partanen, 1988]. An approach to minimizing misclassification error in the NOHS-based JEM might be to determine the percent of employees in an occupational group potentially exposed to an agent being studied, as shown in Table III. Those occupational groups with the highest percentages of employees potentially exposed to the agent might be studied further. The potential for misclassification using this and other JEMs should be explored further.

In using the NOHS-based JEM, it should be remembered that all data included in it are based on field observation and are representative only of those occupational groups and industries observed. Other sources of exposure information, such as the literature or panels of chemists of industrial hygienists, were not used. Field observations were made by teams of surveyors who received a standardized training in industrial hygiene and field techniques, and who followed a standard procedure while collecting and recording data in the field [NIOSH, 1974, 1977, 1978].

Although the JEM may provide additional potential exposure information for health studies, study results are still dependent on the quality of data collected in the study. A common limitation is the lack of a complete work history for which potential exposures in each occupation the worker has had may be determined. Another limitation is confounding of occupations or job titles. Job title or occupation may vary from one industry to another or even vary in the same industry over time. Job titles are especially important in the NOHS-based JEM because of the specific occupation and industry classifications in the JEM. For proper use of the JEM, all occupations should be coded consistently.

Potential exposure data from the JEM may be linked with data from other data sets including physical or carcinogenic properties of the exposure agent. This linkage is possible because the format of the JEM allows cross-referencing of Chemical Abstracts (CAS) codes, Registry of Toxic Effects of Chemical Substances (RTECS) codes, and NIOSH hazard codes.

AVAILABILITY OF THE NOHS-BASED JEM

The NOHS-based JEM file fits on a single reel of magnetic tape for use with a mainframe computer. Extensive documentation on the development and use of the JEM, sample programs to generate results presented in this article, and files including labels corresponding to the numeric codes used throughout the JEM are available from the author. All data retrieval and reporting software is written by using the Statistical Analysis System [SAS, 1979]. Data from the NOHS-based JEM may be downloaded from the mainframe to a microcomputer, and a microcomputer version

TABLE V. No. of Records in Versions of the NOHS-Based JEM File

Version	Classification system		Total no. of records
	Industry	Occupation	
.1	1967 SIC	1970 census	535,771
1.0	1970 census	1970 census	438,073
2.0	1980 census	1980 census	418,867

of the JEM is being developed. Comments from JEM users are welcomed by the authors.

The 1967 SIC industry and 1970 Bureau of the Census occupation codes used in the initial version of the JEM have been converted to other coding systems. Versions of the JEM using 1970 and 1980 Bureau of the Census industry and occupation codes are available. In an edit of industry and occupation codes, 99% of the 16,000 industry and occupation groupings were translated directly from the 1967 SIC to 1970 census industry codes. The number of computer records in each version of the NOHS-based JEM are shown in Table V.

A version of the JEM using the 1972 SIC industry codes is planned for compatibility of the NOHS-based JEM with a similar JEM to be developed by using data from the 1981–1983 National Occupational Exposure Survey (NOES) [NIOSH 1988, 1990a,b]. The NOES is identical to the NOHS but conducted 10 years later.

CONCLUSION

The NOHS-based JEM is based on data from a national U.S. field study. It includes potential exposure data recorded on over 8,000 agents observed in a sample of workplaces covered under the Occupational Safety and Health Act and which employed eight or more workers.

Possible applications of the NOHS-based JEM include the analyses of occupational and environmental health research data. It may be of particular use in registry or other record-based epidemiologic studies where occupational exposure is not limited to a specific facility and where exposure to a specific agent is not easily determined.

ACKNOWLEDGMENTS

The authors acknowledge the contributions of the many individuals in the Surveillance and Support Services Branches of the National Institute for Occupational Safety and Health who helped in the development and application of the job exposure matrix, and in the preparation of the manuscript. The authors gratefully acknowledge helpful comments and review from Dr. Larry Fine, Dr. John Peters, Mr. John Sestito, and Dr. David Garabrant.

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American Journal of Public Health

Reprint

Effectiveness of Source Documents for Identifying Fatal Occupational Injuries: A Synthesis of Studies

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ABSTRACT

Background: The complete and accurate identification of fatal occupational injuries among the US work force is an important first step in developing work injury prevention efforts. Numerous sources of information, such as death certificates, Workers' Compensation files, Occupational Safety and Health Administration (OSHA) files, medical examiner records, state health and labor department reports, and various combinations of these, have been used to identify cases of work-related fatal injuries. Recent studies have questioned the effectiveness of these sources for identifying such cases.

Methods: At least 10 studies have used multiple sources to define the universe of fatal work injuries within a state and to determine the capture rates, or proportion of the universe identified, by each source. Results of these studies, which are not all available in published literature, are summarized here in a format that allows researchers to readily compare the ascertainment capabilities of the sources.

Results: The overall average capture rates of sources were as follows: death certificates, 81%; medical examiner records, 61%; Workers' Compensation reports, 57%; and OSHA reports 32%. Variations by state and value added through the use of multiple sources are presented and discussed.

Conclusions: This meta-analysis of 10 state-based studies summarizes the effectiveness of various source documents for capturing cases of fatal occupational injuries to help researchers make informed decisions when designing occupational injury surveillance systems. (*Am J Public Health.* 1991;81:725–728)

Introduction

Identifying all of the fatal occupational injuries in the United States work force is a difficult task that has not been accomplished with precision.[1,2] Recent literature has questioned the accuracy and completeness of ascertainment of such cases by various sources of information.[1,3–6] Death certificates, Workers' Compensation files, Occupational Safety and Health Administration fatality reports, medical examiner records, reports collected by state health or state labor departments, and various combinations of these have been used to identify cases of fatal work injuries. Each of these sources was developed for different purposes, using different definitions and methods. Because there is no universally accepted gold standard against which to compare, particularly at the national level, it is difficult to measure precisely the proportion of all fatal injuries identified by a specific source.

In a smaller geographic area, such as a state, the pool of fatal work injuries can be defined as the combination of unique cases identified through several sources. Capture rates can then be estimated as the proportion of the total pool identified by each source. This method of assessing the completeness of case ascertainment by various sources of fatal work injury data has been employed in at least 10 states. Results of these studies are summarized here to provide an indication of both the overall average capture rates of the sources, and the variation in capture rates by state.

Sources of Data

The source documents used to identify fatal occupational injuries differ in their primary purposes, methods, and target populations. The advantages and limitations of various sources have been discussed elsewhere.[1,3,7] Issues of validity, completeness, accuracy, timeliness, and the usefulness of data elements in these sources are important considerations in fatality surveillance, but are outside the scope of this paper. The sources examined here are briefly described in terms of their characteristics salient to comparing capture rates.

Death certificates and medical examiner records are the only two available sources that have the potential to identify all cases of fatal work injuries in a given geographic area. Death certificates are filed for each death that occurs in the US and follow a standard format that includes an item indicating whether the death was due to an injury sustained at work. The accuracy and consistency of this item is questionable, however, as no explicit national guidelines exist that define "injury at work."[8,9] Motor vehicle crashes and homicides at work appear to be particularly underreported as work injuries on death certificates.[7,8,10,11]

In most states, medical examiner (ME) or coroner investigations are required for deaths that are due to accidents, homicides, suicides, or deaths that occur unexpectedly.[9] In jurisdictions where ME or coroner records are computerized, or at least centralized, they are a valuable source of information.[12,13] In most states,

From the National Institute for Occupational Safety and Health. Address reprint requests to Nancy Stout, EdD, Division of Safety Research, National Institute for Occupational Safety and Health, 944 Chestnut Ridge Road, Morgantown, WV 26505. This paper, submitted to the Journal September 27, 1990, was revised and accepted for publication February 19, 1991.

TABLE 1—Percent of Fatal Work Injuries Identified by Various Sources: Summary of State-Specific Studies

States	Time Period	N	Source Documents				
			% Death Certificate	% Workers' Compensation	% OSHA Fatality Reports	% Medical Examiner Records	% State Dept Health or Labor
Wisconsin[11]	1976	161	76	57	33		
Maryland[4,a]	1978	148	67	58	42	90	
Michigan[20,b]	1980	195	88				51
Alaska[21]	1980–1985	422	83	47			
Colorado[7]	1982–1984	425	86	66	32		
California[19]	1983	673	90	40	21		
New Jersey[c]	1984–1985	204	84		34	32	
Texas[d]	1986	872	67	70	27		9
Oklahoma[10]	1985–1986	329	78	53	29	82[e]	
Massachusetts[18]	10/86–11/87	86	88	62	41		22
Range (%)			67–90	40–70	21–42	32–90	9–51
Average (%)			81	57	32	68	27

[a]Susan Baker, Johns Hopkins Injury Prevention Center, personal communication, January 1991.
[b]Figures presented here exclude the "natural deaths" from the original study.
[c]Martha Stanbury, New Jersey Department of Health, personal communication, June 1990. New Jersey data exclude intentional injuries.
[d]Texas Department of Health, Occupational Safety and Health Division. Traumatic Occupational Fatalities, 1986. Unpublished report, 1989.
[e]For ME records with unclear work-relatedness, death certificates were reviewed to verify injury at work or reject false positives.

however, both ME and coroner reports exist as fragmented paper files held in various locations throughout a state, they are inconsistent among jurisdictions, and frequently do not indicate the work-relatedness of a fatal injury.[3]

Employers under Occupational Safety and Health Administration (OSHA) jurisdiction are required to report to OSHA all work-related fatalities of employees. Many of these incidents are then investigated and OSHA investigation reports are filed. Not all workers are under OSHA jurisdiction and not all incidents are investigated. Public sector employees, and self-employed workers, for example, are exempt from reporting requirements. Events such as airplane crashes, motor vehicle crashes, and homicides are investigated by other agencies, and are not routinely identified or investigated by OSHA. Recent studies also suggest substantial underreporting of fatalities that do fall under OSHA jurisdiction.[5,7,14–18]

Workers' Compensation claims can provide valuable detail about the nature of fatal injuries and accurate specification of employment. Like OSHA coverage, however, many workers are not covered by Workers' Compensation laws. Moreover, state compensation laws differ substantially so that covered worker populations are not comparable by state, and the national population of covered workers is difficult to define.

In some states, occupational fatalities are reported to the state department of labor or the state department of health. The specific types of employment and fatal events that are reported vary from state to state. For example, in Massachusetts all construction industry employers must report every accident resulting in death. The Massachusetts Department of Labor and Industries maintains records of these and other work-related fatalities reported voluntarily by employers, workers, unions, police, etc.[18]

The State Health Department source of data for the Texas study cited here refers to fatalities reported by employers participating in the Bureau of Labor Statistics (BLS) Annual Survey of Occupational Injuries and Illnesses by Industry. The survey is limited to establishments under OSHA jurisdiction, employing 11 or more workers and, as a sample survey, is not designed to capture all work fatalities.

Differences in capture rates among these sources of fatal work injury data are due in part to variation in types of employments covered by each source. Although several studies have examined capture rates of sources relative to the population covered by law to measure underreporting,[5,7,15,17] the data presented here do not address underreporting of fatal events but rather the potential of various sources to identify the universe of fatal occupational injuries.

Summary of Study Results

In each of 10 studies presented here, multiple data sources were linked, eliminating duplicate cases, to identify a total "pool" of unique fatal occupational injury cases in a state, and the proportion of that pool identified by each separate source. Table 1 summarizes the results of these studies and presents the capture rates for each source, and the range and average capture rates of the combined study results.

All 10 studies used death certificates as one source of case ascertainment and in all but two studies a greater proportion of the total pool of fatal work injuries was identified by death certificates than by any other source. The average capture rate for death certificates over all the studies was 81 percent.

Workers' Compensation files, used as a source of case ascertainment in eight states, had an average capture rate of 57 percent. The wide range (40 to 70 percent) is likely due to the different worker groups covered by the various state compensation laws.

OSHA fatality reports identified an average of 32 percent of cases. The variation in capture rates by state (21 to 42 percent) may be partially due to differences in the OSHA forms examined. In most states, first reports of fatal injuries were used to identify cases. The California[18] and New Jersey[a] studies, however, used OSHA fatality investigation reports. Since not all reported fatalities are inves-

[a]Martha Stanbury, New Jersey Department of Health, Personal Communication, June 1990.

TABLE 2—Percent of Fatal Work Injuries Identified by Only One Source, by Source: Summary of State-Specific Studies

		Sole Source Documents				
States	Time Period	% Death Certificate	% Workers' Compensation	% OSHA Fatality Reports	% Medical Examiner Records	% State Dept. Health or Labor
Wisconsin[11]	1976	43	24	0		
Maryland[4]	1978	(N/A)	(N/A)	(N/A)	(N/A)	
Michigan[20,a]	1980	49				14
Alaska[21]	1980–85	53	17			
Colorado[7]	1982–84	34	14	0		
California[19]	1983	56	7	1		
New Jersey[b]	1984–85	31		3	12	
Texas[c]	1986	26	27	1		<1
Oklahoma[10]	1985–86	2[d]	12	<1	11[d]	
Massachusetts[18]	10/86–11/87	28	17	0		2
Range (%)		2–56	7–27	0–3	11–12	<1–14
Average (%)		36	17	<1	12	5

[a]Figures presented here exclude the "natural deaths" from the original study.
[b]Martha Stanbury, New Jersey Department of Health, personal communication, June 1990. New Jersey data exclude intentional injuries.
[c]Texas Department of Health, Occupational Safety and Health Division. Traumatic Occupational Fatalities, 1986. Unpublished report, 1989.
[d]For ME records with unclear work-relatedness, death certificates were reviewed to verify injury at work or reject false positives.

tigated, first reports are likely to identify a greater proportion of deaths than investigation reports.

Two of the three studies that included ME records identified more cases from ME records than any other source.[4,10] One study used death certificates to verify injury at work for an unknown proportion of ME records on which work relatedness was not indicated; the capture rate would have been lower if ME records had been reviewed independently.[10] In the third study, ME records identified the smallest proportion of cases.[a] This range in capture rates, from 32 percent to 90 percent illustrates the magnitude of variation by state in the potential for ME records to ascertain cases of fatal work injuries.

Occupational fatalities reported to state health departments and state departments of labor under various legislation are grouped together in Table 1 for simplicity. The average capture rate, (27 percent) is presented as a rough indication of the usefulness of such reports for identifying fatal injury cases. This average, however, is based on only three studies, and substantial differences in reporting requirements limit the comparability of these data by state.

Table 2 presents the proportion of the pool of fatal injury cases identified by only one source of information in each study. The range and average sole source capture rates provide an estimate of the proportion of the universe that might be identified by only one specific source and not the others. Obversely, the average for each source presented in this table may be interpreted as the additional proportion of the total pool of cases that might be identified by using this as an additional source of case ascertainment.

These capture rates are a function of the total pool of fatalities identified in each state, and the number and types of source documents used to define that pool. The sole source averages are presented in Table 2 as crude estimates for the purpose of comparison, rather than as precise means.

Over all the studies, death certificates uniquely identified the greatest proportion of fatal work injuries (36 percent), followed by Workers' Compensation records (17 percent), and ME records (12 percent). State labor department records (5 percent) and OSHA fatality reports (less than 1 percent) contributed relatively few additional cases to the total pool.

Discussion

Generally, if surveillance is limited to one source of information, death certificates will likely ascertain a greater proportion of the universe of fatal work injuries than will the other sources examined here. For national level surveillance, death certificates are unique among these sources in their combined potential to identify all fatal work injuries, and their comparability between states. However, the accuracy and consistency with which the injury at work items on death certificates are completed varies by state. Current efforts by the Agency for Vital Records and Health Statistics (AVRHS), National Institute for Occupational Safety and Health (NIOSH), and the National Center for Health Statistics (NCHS) to increase the validity and reliability of this item could vastly improve our ability to identify the universe of fatal occupational injuries at both state and national levels.

Under some jurisdictions, ME records may provide more complete case ascertainment than other sources. However, they also show the greatest variation by state in their ability to identify cases. Efforts to computerize ME records in a consistent format are currently underway in several states. Uniform automation of ME records could substantially improve fatal work injury surveillance within states and enable interstate comparisons.

The combined results of these studies suggest that Workers' Compensation records are not a useful sole source for case ascertainment of work fatalities. As a supplemental source, however, Workers' Compensation records could be expected to add the greatest proportion of cases to a vital records-based system. OSHA fatality reports have limited utility in fatal injury surveillance. Alone, they might be expected to identify about one-third of all cases and, as an additional source, they might capture an additional 1 percent of cases.

Because the definition of state health department and state labor department fatality reports varies so widely by state, generalized conclusions about this source cannot be drawn. In developing surveillance systems, the state-specific characteristics of this potential data source should be considered.

The combined results of these studies highlight several salient points regarding fatal work injury surveillance. The most prominent of these is that using multiple sources of data will always result in more complete case ascertainment than using one source alone.

The value added by including a subsequent source for case ascertainment depends on which source is added and its characteristics within that geographic area. For example, using state labor department records in addition to death certificates in Michigan improved case ascertainment by 14 percent.[20] In the Massachusetts study, however, where

three other sources were also used and where Department of Labor reports had limited coverage, only 2 percent more cases were identified by these records.[18]

In addition to the sources discussed here, other sources should be considered to fill gaps in surveillance systems. For example, all of these sources tend to underreport occupational motor vehicle fatalities and likely undercount homicides. Police report forms and Highway Traffic Administration reports could be valuable in identifying such cases, if efforts were made to include an indication of work-relatedness on these reports.

When designing and developing fatal occupational injury surveillance efforts, cost-benefit analysis and value-added formulas are often considered to determine which sources of data will provide the most effective results given study objective and resource limitations. It is hoped that this synopsis of studies will help researchers make informed decision when designing surveillance systems, recognize limitations of various sources, and support improvements to existing sources so that we might all better understand the magnitude and nature of fatal occupational injuries in the United States. □

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The Identification of Occupational Lung Disease from Hospital Discharge Data

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The Bureau of Labor Statistics-State Health Department Select Committee on Occupational Illnesses and Injuries conducted a study of hospital discharge records to determine their usefulness for identifying cases of occupational disease. Four states searched the diagnosis fields on computerized hospital discharge records for selected occupational lung diseases; pneumoconiosis, extrinsic allergic alveolitis, and respiratory conditions due to chemical fumes and vapors.

The hospital discharge data identified more cases of pneumoconiosis than did the BLS data systems. Numerous cases of extrinsic allergic alveolitis and respiratory conditions due to chemical fumes and vapors were also identified. Patterns evidenced in the data were generally consistent with current knowledge of the diseases. The inclusion of industry and occupation on the hospital discharge record, further study of the quality of diagnosis coding, and the use of these data by additional states will enhance the usefulness of these data for occupational disease surveillance.

The Occupational Safety and Health Act of 1970 gave the Secretary of Labor the responsibility of developing and maintaining "an effective program of collection, compilation, and analysis of occupational safety and health statistics." The Bureau of Labor Statistics (BLS) was designated to carry out these activities.

Accurate occupational injury and illness data are essential for effective accident and illness prevention. The data are needed for studying the causes of occupational injuries and illnesses, setting occupational safety and health standards, determining priorities for inspecting workplaces, administering compensation and health care programs, and evaluating the efficacy of control measures.

Because of the need for better occupational illness data, in 1985 the BLS sponsored a symposium, "Towards Improved Measurement and Reporting of Occupational Illness and Disease," that brought together a wide variety and depth of expertise of federal and state labor and health department officials, medical and public health personnel, academia, management, and labor. Representatives from all fifty states and several territories participated.

During the symposium, representatives from several state health departments met to offer the BLS their assistance in this area. The BLS-State Health Department Select Committee on Occupational Illnesses and Injuries resulted from that meeting. State health departments of six states are represented on the committee: California, New Jersey, New York, Texas, Utah, and Wisconsin. (Committee members' names are available from author.)

The first project initiated by the committee was to assemble hospital discharge information provided to four of the member states by participating hospitals. Several states had found these data to be useful in identifying cases of certain conditions that are considered to be almost entirely work related.[1] This report describes the findings of the project.

Methods

Hospital discharge records contain information on patients who were admitted to an acute care, nonfederal hospital. Data for hospitalizations occurring in federally

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The opinions expressed in this article do not necessarily reflect the views of the Bureau of Labor Statistics.

0096-1736/91/3810-1060$3.00/0

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owned hospitals, such as military and Veterans' Administration hospitals, and in institutions providing long-term care (such as nursing homes or psychiatric institutions) are excluded from the study.

The hospital discharge record contains data on demographic characteristics of the patient, including birthdate, sex, race or ethnic group, and marital status; administrative information, including admission and discharge dates; and medical information, including diagnoses and surgical and nonsurgical procedures, both of which are coded according to the *International Classification of Diseases*, 9th edition (ICD-9).

Because hospital discharge records generally do not contain information on the occupation and industry of the patient or other indication of workplace exposures, the committee selected seven ICD-9 categories that include diseases widely recognized to be work related (Table 1).

TABLE 1
Work-Related ICD-9* Categories

Diseases	ICD-9 Code
Extrinsic allergic alveolitis—includes allergic alveolitis and pneumonitis due to inhaled organic dust particles of fungal, thermophilic actinomycete, or other origin	495
Farmers' lung	495.0
Bagassosis (sugar cane pulp)	495.1
Bird fanciers' lung	495.2
Suberosis (cork)	495.3
Maltworkers' lung (Aspergillus clavatus)	495.4
Mushroom workers' lung	495.5
Maple-bark-strippers' lung	495.6
"Ventilation" pneumonitis	495.7
Other specified allergic alveolitis and pneumonitis	495.8
Unspecified allergic alveolitis and pneumonitis	495.9
Coal workers' pneumoconiosis	500
Anthracosilicosis	
Anthracosis	
Black lung disease	
Coal workers' lung	
Miners' asthma	
Asbestosis	501
Pneumoconiosis due to other silica or silicates	502
Pneumoconiosis due to talc	
Silicotic fibrosis (massive) of lung	
Silicosis (simple or complicated)	
Pneumoconiosis due to other inorganic dust	503
Aluminosis (of lung)	
Bauxite fibrosis (of lung)	
Berylliosis	
Graphite fibrosis (of lung)	
Siderosis (iron)	
Stannosis (tin)	
Pneumonopathy due to inhalation of other dust	504
Byssinosis (cotton)	
Cannabinosis (hemp)	
Flax-dressers' disease	
Respiratory conditions due to chemical fumes and vapors	506
Bronchitis and pneumonitis	506.0
Acute pulmonary edema	506.1
Upper respiratory inflammation	506.2
Other acute and subacute respiratory conditions	506.3
Chronic respiratory conditions	506.4
Unspecified respiratory conditions	506.9

* *International Classification of Diseases*, 9th rev.

TABLE 2
States Providing Hospital Discharge Data

State	Year	Number of Diagnosis Fields Used
California	1984	24
New Jersey	1984–1985	9
New York	1985	5
Wisconsin	1980–1983*	5

* Annual estimates for Wisconsin are based on hospital discharge data for 1 month of the year. Because of the resulting variation in the data, these estimates were averaged over the 4 years for inclusion in the tables. Wisconsin currently collects hospital discharge records for the entire year and has begun to record usual industry and occupation for all persons admitted to a hospital.

A case was included if the ICD code for one of the occupational diseases being studied was found in either the primary or one of the secondary diagnosis fields on the record. The occupational condition was, therefore, present at the time of the patient's hospitalization but may not have been the primary reason for the hospitalization.

Duplicate records for persons hospitalized more than once during the year were deleted from the data for each state except Wisconsin. The possibility of duplicates on Wisconsin's file is small because of the estimation procedure used. Duplicate admissions were identified by matching birth date, sex, race, and zip code. Records for persons hospitalized in previous years were not deleted.

States submitted hospital discharge information for one or more years for which the data were complete and easily accessible. Table 2 lists the states and the years for which hospital discharge data were provided as well as the number of diagnosis fields used to identify cases of the selected occupational diseases.

Tabulations of the data by sex, age, racial/ethnic group, and diagnosis field were generated and analyzed. Data were compared with data from BLS's Annual Survey of Occupational Injuries and Illnesses and the Supplementary Data System.

Findings

Distribution of the Data

Asbestosis predominated among the diagnoses entered on the hospital discharge records selected for study in all states except Wisconsin (see Table 3). New Jersey's totals for asbestosis surpassed those for California and New York although New Jersey currently has fewer workers in industries with asbestos exposure—construction, the manufacture of asbestos products, shipbuilding and repair, and brake-lining repair.[2,3] Historically, however, New Jersey had a large number of workers employed in primary asbestos manufacturing and in shipbuilding.[4]

Coal workers' pneumoconiosis was also prominent among the hospitalizations reported. These totals may seem surprising for non-coal mining states. However, there is a similar widespread distribution of patients

nationwide who receive compensation benefits for black-lung disease.

Hospitalizations of persons with respiratory conditions due to chemical fumes and vapors were also prominent in California's and New York's data; over half these were cases of bronchitis or pneumonitis. In Wisconsin, hospitalizations involving extrinsic allergic alveolitis predominated among the seven disease categories, followed closely by silicotic conditions.

Approximately 80% of patients hospitalized with the selected occupational conditions were men (Table 4), but this ratio varied greatly by disease. Asbestosis and silicosis were predominantly found in men. This predominance existed, but to a lesser extent, for the other pneumoconioses and for respiratory conditions due to chemical fumes and vapors.

The relatively high proportion of women among those hospitalized with coal workers' pneumoconiosis needs further study. The proportion of women employed in coal mining is much lower, ranging from 2% in 1960 to 6% in 1985. The proportion of women in blue-collar occupations in bituminous coal mining is even smaller (0.1%) according to a study conducted by the US Equal Employment Opportunity Commission in 1975.[5–7]

Over half the cases of extrinsic allergic alveolitis reported in California's and New Jersey's hospital discharge data were among women. These were the only instances in the study where female patients predomi-

TABLE 3

Patients Hospitalized with Selected Occupational Diseases (ICD-9* Code), Four States, Selected Years†

Year and State	Total‡ (No.)	Extrinsic Allergic Alveolitis (495)	Coal Workers' Pneumoconiosis (500)	Asbestosis (501)	Pneumoconiosis from Silica or Silicates (502)	Pneumoconiosis from Other Inorganic Dust (503)	Pneumonopathy from Inhalation of Other Dust (504)	Respiratory Conditions from Chemical Fumes/Vapors (506)
1985								
New Jersey	1,210	41	228	717	82	8	6	128
(%)	(100.0)	(3.4)	(18.8)	(59.3)	(6.8)	(0.7)	(0.5)	(10.6)
New York	886	109	175	251	122	17	12	200
(%)	(100.0)	(12.3)	(19.8)	(28.3)	(13.8)	(1.9)	(1.4)	(22.6)
1984								
California	1,675	153	264	697	132	18	13	398
(%)	(100.0)	(9.1)	(15.8)	(41.6)	(7.9)	(1.1)	(0.8)	(23.8)
New Jersey	998	41	193	568	77	14	2	103
(%)	(100.0)	(4.1)	(19.3)	(56.9)	(7.7)	(1.4)	(0.2)	(10.3)
1980–1983§								
Wisconsin	348	111	15	42	96	6	9	69
(%)	(100.0)	(31.9)	(4.3)	(12.1)	(27.6)	(1.7)	(2.6)	(19.8)

* ICD-9 = *International Classification of Diseases*, 9th rev.
† State hospital discharge records.
‡ Percents may not total 100.0 due to rounding.
§ Average for the four years, based on estimates.

TABLE 4

Percent of Men *versus* Women Hospitalized with Selected Occupational Diseases (ICD-9* Code), Four States, Selected Years†

Year, State, Sex	Total‡ (No.)	Extrinsic Allergic Alveolitis (495)	Coal Workers' Pneumoconiosis (500)	Asbestosis (501)	Pneumoconiosis from Silica or Silicates (502)	Pneumoconiosis from Other Inorganic Dust (503)	Pneumonopathy from Inhalation of Other Dust (504)	Respiratory Conditions from Chemical Fumes/Vapors (506)
1985								
New Jersey								
Men	84.2 (1019)	43.9	78.5	92.3	90.2	87.5	66.7	58.6
Women	15.8 (191)	56.1	21.5	7.7	9.8	12.5	33.3	41.4
New York								
Men	80.1 (710)	61.5	81.7	98.4	91.0	76.5	66.7	60.5
Women	19.9 (176)	38.5	18.3	1.6	9.0	23.5	33.3	39.5
1984								
California								
Men	76.5 (1281)	43.8	75.4	92.8	90.9	72.2	61.5	57.0
Women	23.5 (394)	56.2	24.6	7.2	9.1	27.8	38.5	43.0
New Jersey								
Men	83.5 (833)	39.0	74.1	93.7	85.7	57.1	50.0	65.0
Women	16.5 (165)	61.0	25.9	6.3	14.3	42.9	50.0	35.0
1980–1983§								
Wisconsin								
Men	77.6 (270)	64.9	60.0	92.9	90.6	50.0	100.0	73.9
Women	22.4 (78)	35.1	40.0	7.1	9.4	50.0	0.0	26.1

* ICD-9 = *International Classification of Diseases*, 9th rev.
† State hospital discharge records.
‡ Percents may not total 100.0 due to rounding.
§ Average for the four years, based on estimates.

TABLE 5
Percent Distribution of Patients Hospitalized with Selected Occupational Diseases (ICD-9* Code) by Sex, Four States, Selected Years†

Year, State, Sex	Total‡ (No.)	Extrinsic Allergic Alveolitis (495)	Coal Workers' Pneumoconiosis (500)	Asbestosis (501)	Pneumoconiosis from Silica or Silicates (502)	Pneumoconiosis from other Inorganic Dust (503)	Pneumonopathy from Inhalation of Other Dust (504)	Respiratory Conditions from Chemical Fumes/Vapors (506)
1985								
New Jersey								
Men	100.0 (1019)	1.8	17.6	65.0	7.3	0.7	0.4	7.4
Women	100.0 (191)	12.0	25.7	28.8	4.2	0.5	1.0	27.7
New York								
Men	100.0 (710)	9.4	20.1	34.8	15.6	1.8	1.1	17.0
Women	100.0 (176)	23.9	18.2	2.3	6.3	2.3	2.3	44.9
1984								
California								
Men	100.0 (1281)	5.2	15.5	50.5	9.4	1.0	0.6	17.7
Women	100.0 (394)	21.8	16.5	12.7	3.0	1.3	1.3	43.4
New Jersey								
Men	100.0 (833)	1.9	17.2	63.9	7.9	1.0	0.1	8.0
Women	100.0 (165)	15.2	30.3	21.8	6.7	3.6	0.6	21.8
1980–1983§								
Wisconsin								
Men	100.0 (270)	26.7	3.3	14.4	32.2	1.1	3.3	18.9
Women	100.0 (78)	50.0	7.7	3.8	11.5	3.8	0.0	23.1

* ICD-9 = *International Classification of Diseases*, 9th rev.
† State hospital discharge records.
‡ Percents may not total 100.0 due to rounding.
§ Average for the 4 years, based on estimates.

TABLE 6
Percent Distribution of Patients Hospitalized with Selected Occupational Diseases (ICD-9*) by Sex and Age, Four States, Selected Years†

Sex, Age	Total‡	Extrinsic Allergic Alveolitis (495)	Total Pneumoconioses (500–504)	Respiratory Conditions from Chemical Fumes/Vapors (506)
Men				
All ages				
No.	3280	224	2582	474
%	100.0	100.0	100.0	100.0
<16	3.0	1.8	0.3	18.1
16–24	2.4	7.1	0.1	13.1
25–54	16.1	36.2	8.7	46.6
55+	78.5	54.9	90.9	22.2
Women				
All ages				
No.	839	190	328	321
%	100.0	100.0	100.0	100.0
<16	6.3	4.7	0.9	12.8
16–24	4.5	3.2	0.6	9.3
25–54	31.5	38.4	18.0	41.1
55+	57.7	53.7	80.5	36.8

* ICD-9 = *International Classification of Diseases*, 9th rev.
† State hospital discharge records from four States combined: California (1984), New Jersey (1985), New York (1985), and Wisconsin (1980–1983, average for the four years, based on estimates).
‡ Percents may not total 100.0 due to rounding.

nated among the hospitalizations involving one of the seven diseases.

Table 5 shows the distribution of patient hospitalizations involving the seven occupational diseases for each sex. Asbestosis was reported most frequently in the hospital data for men in California, New Jersey, and New York. In Wisconsin, silicosis was the most prevalent of the diseases reported for men; extrinsic allergic alveolitis was second.

Respiratory conditions due to chemical fumes or vapors and extrinsic allergic alveolitis were involved in about two-thirds of the hospitalizations studied among women in California, New York, and Wisconsin. In New Jersey, asbestosis was the most common diagnosis among women, possibly reflecting the presence of women workers in the state's asbestos textile industry[4] or in shipbuilding during World War II.

The distribution of patients hospitalized with one of the seven disease categories by age and sex is shown in Table 6 for the four states. Except for respiratory conditions due to chemical fumes and vapors, most of the persons hospitalized with one of the seven diseases were 55 years or older. This pattern is generally consistent with what is known about the diseases being studied. Pneumoconioses are known to have prolonged latency periods and tend to be found in older persons.[2] On the other hand, respiratory conditions such as bronchitis and pneumonitis (ICD code 506) have varied latencies and are not specific to particular age groups.

Comparing these data by sex, women hospitalized with pneumoconiosis were slightly younger than men, whereas men hospitalized with either extrinsic allergic alveolitis or respiratory conditions due to chemical fumes and vapors tended to be slightly younger than women hospitalized with these conditions.

An observation about the age distribution of those hospitalized with these diseases is the number of patients younger than 16 years old, particularly among those with respiratory conditions caused by chemical fumes and vapors. These numbers may indicate either the presence of children in certain types of work or, alternatively, that some of these cases resulted from nonoccupational exposures.

Table 7 shows the diagnosis fields in which the seven diseases were captured. In most cases, the diseases were identified based on one of the secondary diagnoses. In

TABLE 7
Percent Distribution of Selected Occupational Diseases (ICD-9*) Identified in Primary or Other Diagnoses, Four States, Selected Years†

Diagnosis‡	Total§	Extrinsic Allergic Alveolitis (495)	Total Pneumoconioses (500–504)	Respiratory Conditions from Chemical Fumes/Vapors (506)
Total (No.)	4119	414	2910	795
Primary diagnosis	21.2	49.3	9.4	49.9
Other diagnoses	78.8	50.7	90.6	50.1

* ICD-9 = *International Classification of Diseases*, 9th rev.
† State hospital discharge records from four states combined: California (1984), New Jersey (1985), New York (1985), and Wisconsin (1980–1983, average for the 4 years, based on estimates).
‡ New York and Wisconsin provided data for the hospitalization if one of the seven diseases was identified in any of the five diagnosis fields. California provided the data if the disease was identified in any of the 24 diagnosis fields on the record, and New Jersey if the disease was found in one of nine diagnosis fields.
§ Percents may not total 100.0 due to rounding.

other words, these diseases either contributed to the condition constituting the primary reason for the hospitalization—the primary diagnosis—or existed as an independently diagnosed disease present at the time of the hospitalization.

Table 8 shows New York's hospital discharge data by diagnoses in greater detail. These data show that the pneumoconioses tend to appear in the more remote diagnosis fields. Over half the hospitalizations in New York involving pneumoconioses were captured in the third, fourth, or fifth diagnosis fields. Alternatively, almost half the hospitalizations involving extrinsic allergic alveolitis and respiratory conditions due to chemical fumes and vapors were captured in the primary diagnosis field.

TABLE 8
Distribution of Hospitalizations Involving Selected Occupational Diseases by Order of Diagnosis, New York, 1985*

Disease	Total No.	Number Identified in 1st Diagnosis	2nd Diagnosis	3rd, 4th, or 5th, Diagnosis
Total	886	241	259	386
Extrinsic allergic alveolitis	109	52	30	27
Farmer's lung	24	10	8	6
Bagassosis	2	1	0	1
Bird fanciers' lung	9	4	1	4
"Ventilation" pneumonitis	1	1	0	0
Other specified	14	8	4	2
Unspecified	59	28	17	14
Coal workers' pneumoconiosis	175	38	43	94
Asbestosis	251	27	69	155
Pneumoconiosis due to other silica or silicates	122	20	41	61
Pneumoconiosis due to other inorganic dust	17	2	5	10
Pneumonopathy due to inhalation of other dust	12	3	4	5
Respiratory conditions due to chemical fumes and vapors	200	99	67	34
Bronchitis and pneumonitis	111	51	42	18
Acute pulmonary edema	6	3	1	2
Upper respiratory inflammation	4	1	1	2
Other acute and subacute conditions	44	22	15	7
Chronic conditions	20	8	8	4
Unspecified	15	14	0	1

* State hospital discharge records.

Comparison with BLS Illness Data

BLS conducts two data-collection programs that gather information on occupational injuries and illnesses—the Annual Survey of Occupational Injuries and Illnesses and the Supplementary Data System (SDS).

The annual survey is a sample survey of about 280,000 private sector establishments nationwide. Sampled employers are required to report all new occupational illnesses for the survey year. (The survey defines an occupational illness as any abnormal condition or disorder caused by exposure to environmental factors associated with employment, providing the exposure did not result from a single instantaneous event.) Occupational illnesses are classified into one of seven categories. Two of these categories deal specifically with respiratory conditions: dust diseases of the lungs and respiratory conditions due to toxic agents.

States participating in the SDS provide injury and illness information from state workers' compensation reports. Nature of injury or illness is coded into a number of different categories expanded from the American National Standards Institute Z16.2-1962 *Method of Recording Basic Facts Relating to the Nature and Occurrence of Work Injuries.*

Table 9 compares the hospital discharge data from the four states with annual survey data for the entire United States and with SDS data for the 23 states providing workers' compensation cases resulting in death or disability that either occurred or were received during 1985. Table 10 compares the hospital discharge data and available BLS data for three states: California, New York, and Wisconsin.

More pneumoconiosis cases were captured in the hospital discharge data from the four states than in either of the two BLS national or "seminational" data systems. Employment covered under the hospital discharge data from the four states constitutes from 25% to 30% of the employment covered by the annual survey. Although the hospital discharge data cover the entire population of the state, the annual survey data cover only private sector workers. Coverage under the SDS is dependent on the individual state workers' compensation laws. Generally, these laws cover most private-sector employees except for those working in casual employments or those covered by federal compensation programs or

TABLE 9

Selected Occupational Illness Data from Hospital Discharge (HD) Records, Supplementary Data System (SDS), and Annual Survey

Occupational Disease	HD ICD-9* Code	SDS Nature Code	Hospital Discharge Data (4 States)†	SDS Disability Data (23 States)‡ 1985	Annual Survey Data (Total US) 1985
Total pneumoconioses	500–504	280–289	2,910	1,191	1,700§
Coal workers' pneumoconiosis	500	282	682	760	NA
Asbestosis	501	283	1,707	215	NA
Silicosis	502	286	432	128	NA
Pneumoconiosis due to other inorganic dust	503	281, 285, 287, 289	49	46	NA
Pneumonopathy due to inhalation of other dust (byssinosis)	504	284	40	3	NA
Unspecified pneumoconiosis	505	280	NA‖	39	NA
Total respiratory conditions due to inhalation of chemical fumes and vapors¶	506	273, 274	795	1,879	11,600§

* ICD-9 = *International Classification of Diseases*, 9th rev.

† Hospital discharge data are for California (1984), New Jersey (1985), New York (1985), and Wisconsin (1980–1983, averaged for the 4 years, based on estimates).

‡ SDS data are for the following states (figures in parentheses are the minimum number of days of disability required for the case to be included): Alaska (1), Arizona (8), California (1), Colorado (4), Hawaii (1), Indiana (1), Iowa (3), Kentucky (1), Louisiana (7), Maryland (4), Michigan (8), Mississippi (8), Missouri (1), Nebraska (1), New Mexico (8), Ohio (1), Oregon (1–4), Tennessee (8), Utah (1), Virginia (8), Washington (4), Wisconsin (4), and Wyoming (1).

§ Data are rounded to the nearest hundred.

‖ NA = not available.

¶ SDS data are records with nature code 273 or 274 (respiratory conditions due to toxic exposures); type code 181 (inhalation); and source code 0900–0999 (chemicals), 1140 (hydrocarbon gases), or 1700 (flame, fire, and smoke). Annual survey data shown exclude cases resulting from instantaneous exposures but may include some cases of extrinsic allergic alveolitis or acute congestion due to inhalation of dusts.

TABLE 10

Selected Occupational Illness Data from Hospital Discharge (HD) Records, Supplementary Data System (SDS), and Annual Survey (AS) for Selected States and Years*

Disease†	California			New York		Wisconsin	
	HD 1984	SDS 1985	AS 1984	HD 1985	SDS 1985	HD‡ 1980–1983	SDS 1983
Total pneumoconioses	1124	14	239	577	80	168	36
Coal workers' pneumoconiosis	264	–	NA§	175	–	15	–
Asbestosis	697	8	NA	251	34	42	5
Silicosis	132	4	NA	122	30	96	25
Pneumoconiosis due to other inorganic dust	18	2	NA	17	2	6	1
Pneumonopathy due to inhalation of other dust (byssinosis)	13	–‖	NA	12	1	9	–
Unspecified pneumoconiosis	NA	–	NA	NA	13	NA	5
Total respiratory conditions due to inhalation of chemical fumes and vapors¶	398	1507	2293	200	105	69	75

* SDS data are not available for even-numbered years beginning with 1982 and are not available for New Jersey beginning with 1981. SDS data include workers' compensation cases received during the year that involved death, permanent disability, or 1 or more days of disability for California or 4 or more days for Wisconsin. New York's SDS data include those cases involving death, permanent disability, or 8 or more days of disability and either reached end of payment or final determination during the year. Annual survey data are not available for New Jersey, New York, and Wisconsin.

† Disease codes are the same as shown in Table 9.

‡ Average for the 4 years, based on estimates.

§ NA = data not available.

‖ – = no data reported.

¶ SDS data are records with nature code 273 or 274 (respiratory conditions due to toxic exposures); type code 181 (inhalation); and source code 0900–0999 (chemicals), 1140 (hydrocarbon gases), or 1700 (flame, fire, and smoke). Annual survey data shown exclude cases resulting from instantaneous exposures but may include some cases of extrinsic allergic alveolitis or acute congestion due to inhalation of dusts.

employer liability laws, such as the Black Lung and Longshoremen's and Harbor Workers' Compensation Programs. Some cases of coal workers' pneumoconiosis and asbestosis would, therefore, escape capture in the SDS. State and local government employees are usually covered by state workers' compensation laws.

The BLS systems appear to perform better for acute conditions, such as some respiratory conditions due to chemical vapors and fumes, rather than for chronic conditions. No firm conclusions regarding the accuracy of the hospital discharge data for respiratory conditions due to inhalation of chemical fumes and vapors can be made from the comparison with the BLS data systems. The comparison is hampered by differences in the num-

ber of states for which data are available, differences in coding structures, and differences in the scope of cases covered by the systems.

Summary and Conclusions

The large number of persons hospitalized with the conditions selected for the study suggest that hospital discharge records are useful in identifying cases of certain occupational conditions. Many of the diseases selected for the study, particularly the various types of pneumoconioses, have long latency periods and occur after a number of years of exposure to the agent. These conditions, which may not be diagnosed until after the patient leaves employment, will be underreported in data systems based on employers' records (BLS annual survey) or worker compensation records (Supplementary Data System).

Almost three times as many cases of pneumoconiosis were reported in the hospital discharge system from the four states participating in this study (Table 9) as from worker compensation records in 23 states; and almost two times as many cases were reported in the hospital discharge system from the four states as from employer records in 50 states. However, for respiratory conditions due to inhalation of chemicals or vapors, the worker compensation data and the employer records were more complete.

Although hospital discharge data are more comprehensive for the chronic pneumoconioses than is the current BLS system, it too will miss cases. Hospital discharge data identify only those cases in which the patient has been hospitalized, either for the disease being studied or for some other condition.

The number of women with coal workers' pneumoconiosis suggest that further study is needed to confirm the accuracy of the diagnosis coding for certain diseases on the hospital discharge records. Backtracking of silicosis patients in New Jersey confirmed the diagnosis in approximately 80% of the patients studied and confirmed that another 10% had some type of work-related pneumoconiosis.[1]

A registry of occupational illness cases drawn from hospital discharge records that eliminates duplicate admissions is possible in many states. State health departments would thus be able to create hospital-based incidence figures for these diseases and to examine the geographic distribution of cases and trends over time. Hospital discharge data would be one component of a comprehensive surveillance system using multiple data sources.[8]

Once a case is identified, the state health or labor department could contact the patient for an employment history to determine possible sources of exposure. Industrial hygiene follow-up would be conducted in suspect plants to ascertain whether exposures in the plant continue, whether other workers are affected, and what corrective actions are needed. Cases resulting from exposures in another state, as may be the case for coal workers' pneumoconiosis in this study, could be referred to the appropriate state or federal agency.

The inclusion of occupation and industry on hospital discharge records would allow the use of hospital discharge data for surveillance of conditions that are not always occupationally related. Connecticut and Wisconsin currently require industry and occupation to be included on all hospital discharge records. The Sentinel Health Event algorithm could then be applied to hospital discharge data.[9] Inclusion of industry and occupation for all hospitalizations also would allow epidemiologists to form hypotheses concerning increased risks for developing various conditions among workers in certain industries and occupations.

The BLS-State Health Department Select Committee was established to focus on potential improvements in the quality and usefulness of occupational illness and injury statistics. The project described in this article was undertaken to test a new approach to occupational disease surveillance. The data were collected with minimal effort and cost from existing data sets in four states.

The findings indicate that using hospital discharge data is a feasible method for surveillance of well-recognized occupational diseases and could be expanded to the other 16 states that collect hospital discharge data. Data from the National Hospital Discharge Survey administered annually since 1965 by the National Center for Health Statistics and from the Veterans Administration's Discharge Data System should be evaluated for use in developing a national surveillance system.

Acknowledgments

Work was accomplished under the auspices of the Bureau of Labor Statistics-State Health Department Select Committee on Occupational Illnesses and Injuries. The project was funded by the Bureau of Labor Statistics.

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PART IV

1991 National Conference on State-Based Occupational Safety and Health Activities: Abstracts Related to NIOSH Surveillance Activities

National Conference on State-based Occupational Health and Safety Activities
September 3-6, 1991

Conference Abstracts

National Goals for Occupational Lung Diseases: Focus on State-Specific Patterns

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The eradication of silicosis, byssinosis, asbestosis, and coal workers' pneumoconiosis has been a broad national objective. The Public Health Service's "Year 2000 Objectives for the Nation" continues to note the importance of the prevention of these occupational lung diseases. Mortality surveillance is one method by which to both evaluate and focus efforts toward meeting these objectives. State-specific analyses can identify geographic patterns useful for encouraging preventive efforts at the state level.

The majority of analyses using death certificate data are based on rates tabulated from underlying cause of death only. For public health purposes of identifying occupational diseases, multiple cause of death listings are a more appropriate source of data. We used multiple cause of death data tapes, from the National Center for Health Statistics, to identify deaths occurring in U.S. residents with mention of coal workers' pneumoconiosis, silicosis, asbestosis, and byssinosis on the death certificate. Temporal trends and geographic distributions for each of these four lung diseases were developed for 1979-1987.

Differing trends and geographic patterns were evident for each of the four diseases. For 1979-1987 over 70% of deaths with mention of CWP occurred in only two states. Deaths with mention of byssinosis, although smaller in number, are clustered as well, with over 50% occurring in two states. Mentions of silicosis and asbestosis occurred in a more diffuse pattern. Six states accounted for 48% of deaths with mention of silicosis, and approximately 52% of deaths with mention of asbestosis were distributed in six states. Although the public health objectives calling for the control of these four occupational lung diseases are national in scope, it appears that focused efforts in specific states may be warranted to achieve the overall goals.

Investigation of a Sentinel Case of Asbestosis in a Paper Manufacturing Company

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In 1985 the Wisconsin Division of Health began an occupational disease surveillance program which included providing pneumoconiosis diagnosis consultation to clinicians by providing chest radiograph pneumoconiosis classification by a "B-Reader." In 1987, with the aid of the consultation program, a case of asbestosis was diagnosed in an electrician from a paper manufacturing plant. An earlier case in a painter/insulator from the same plant was identified in the consultation files. An industrial hygiene review of the facility assisted in identifying possible sources of asbestos exposure, all amenable to control. An unrecognized hazard was found in the paper drying machine hoods which contained asbestos for heat insulation. A common work practice was to use compressed air to clean paper dust out of the hood. A medical surveillance and asbestos control program was begun by the company. Fifty-one (18%) of 283 workers screened had abnormal radiographs. Pleural

thickening was the most prevalent abnormality seen in 39 (76%) of the 51 abnormal films. The mesothelioma surveillance system was searched, identifying cases of mesothelioma with usual occupation and industry indicating paper manufacturing employment.

Surveillance of Occupational Pesticide Poisoning in Oregon

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The sentinel event surveillance model has been used to evaluate occupational pesticide poisoning in Oregon since November 1987. An overview of three years of case investigation data will be presented (169 case reports including 320 symptomatic occupationally-exposed individuals) in the context of the surveillance model. Pesticide poisoning represents a broad range of often ill-defined syndromes and symptomatology. In addition, health care may be given by a large population of primary care providers. There are two separate agencies in the state with jurisdiction over aspects of pesticide use and worker protection. Our experience in creating a network of educated health care providers as reporters of occupational pesticide poisonings, including the critical role of the Oregon Poison Center will be described. Mechanisms for coordination of investigation and intervention activities with overlapping agency jurisdiction have been implemented. Issues of confidentiality, and barriers to physician reporting and investigation of pesticide poisonings of farmworkers will also be discussed.

Evaluation of Occupational Mortality Surveillance

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Thirty-three states code the industry and occupation information from death certificates and many use the data as a component in their occupational health surveillance programs. The National Institute for Occupational Safety and Health has developed an occupational mortality surveillance system based on these data from selected states. We describe the surveillance system and an evaluation that focused on the use of occupational mortality data for identifying work-related disease. A review of the literature showed that occupational mortality data, despite known limitations, have often been used successfully for development of hypotheses about work-related disease and for prioritization of epidemiologic research. We found good agreement between associations identified using the mortality data and those found in more rigorous studies using population-based cancer registries with interview data. We demonstrated a method to develop hypotheses of associations by comparing the results of occupational mortality analyses across countries. In addition to identifying work-related disease, states have used the data in union and industry educational programs, as a source of information for researchers, in reports on disease or occupation, and to identify worker educational needs.

Uses of Occupational Mortality Data in Massachusetts

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The Massachusetts Department of Public Health has been collecting and coding occupation and industry information on death certificates since 1982. These data have been used in a number of different ways to examine work-related illnesses and injuries within Massachusetts. Examples include: studies of traumatic occupational deaths, short and long latency respiratory diseases and cancer. The employment data on death certificates has also been used as an adjunct to employment information in the Massachusetts Cancer Registry and as an indicator of socio-economic status in the investigation of access to medical care. The collection of employment information on death certificates is a limited but important component of a comprehensive occupational health surveillance system. Alternatives for coding and analyzing these data will be discussed.

Occupational Health and Minority Workers

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Disparities of health status among ethnic and racial groups are a major public health concern in Massachusetts. Despite improvement of health status and life expectancy, people of color are disproportionately affected by adverse health outcomes. Black and hispanic residents bear the brunt of illnesses and deaths related to chronic disease, substance abuse, AIDS, poor perinatal outcomes and injuries. There is a growing body of evidence in the literature that people of color are also disproportionately exposed to occupational hazards. New evidence from Massachusetts will be reviewed and the importance of addressing racial and ethnic differences in the development of state-based occupational health programs will be discussed. Strategies range from collecting adequate race and ethnic information in public health data systems to the development of linguistically and culturally appropriate educational materials and programs for workers.

An Overview of the NIOSH State-Based Fatal Accident Circumstances and Epidemiology Project

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In October 1989, NIOSH, through its Division of Safety9Research (DSR), sponsored cooperative agreements for conducting selected fatality investigations at the state level using the Fatal Accident Circumstances and Epidemiology (FACE) research methodology. Three states--Colorado, New Jersey, and Massachusetts--were provided funds to conduct FACE-type fatality investigations through state departments of Health and/or Labor. All state programs, although structured differently, have a surveillance component for identifying electrocution, fall and confined space-related fatalities, and an investigation component for conducting on-site investigations. The state-based FACE activities complement the in-house NIOSH FACE program, and share the goal of identifying factors that may increase the risk of work-related fatal injury. State-based FACE investigations provide states with the ability to target specific research and prevention efforts within their state. State intervention strategies should enable more effective fatality countermeasures to be developed and implemented by employers, employees, and state and federal regulatory agencies. State-based FACE program activities in fiscal year 1990 were committed to developing notification systems, recruiting and training personnel, evaluating intervention strategies, and conducting 38 FACE-type investigations. NIOSH DSR support activities, project start-up lessons and future program directions will be discussed. The ultimate goal of this project is to conduct FACE investigations of all work-related deaths at the state level.

The NIOSH Farm Family Health and Hazard Surveillance Program

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The National Institute for Occupational Safety and Health (NIOSH) is the Federal Agency mainly responsible for conducting research on the occupational safety and health of the U.S. work force. Farmers are an important part of this work force. The infrastructure of universities, County Extension Services, and State Health Departments is the focal point for NIOSH funding of a surveillance program that describes the health status of farm families and the hazards of farming. The results of these surveys will be a first step in the prevention of work related injury and disease. Six cooperative agreements awarded in September 1990 averaged $194,000 for the first year of a five year program. Survey designs differ with respect to commodity (grain, dairy, livestock, etc.), geography (statewide or selected counties), demography (all age/sex or selected groups), targeted diseases and injuries and selected physical, chemical or biological hazards. Each state's survey strategies reflects their specific priorities, perceptions of opportunity for research, and goals for disease and injury prevention.

Developing a Nurse-Based Occupational Health and Safety Infrastructure in Agricultural Communities

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Nurses are essential components of the public health infrastructure, particularly in rural communities. This program, entitled "Occupational Health and Safety Surveillance through Health Departments and Nurses in Agricultural Communities," is an effort to extend public health nursing into the arena of agricultural health and safety. Through ten cooperative agreements averaging $235,000, the National Institute for Occupational Safety and Health is funding the placement of 31 nurses in agricultural communities. These nurses will conduct active surveillance for agriculture-related illness and injury in the states of California, Georgia, Iowa, Kentucky, Maine, Minnesota, New York, North Carolina, North Dakota, and Ohio, performing educational and other interventions as needed. Project nurses will also provide health care providers with educational materials and referrals to consultants in universities, state and federal government and Agricultural Extension services. This program provides an opportunity to assess the effectiveness of various methods of enhancing provider-based reporting and to identify the extent to which various agriculture related illnesses are amenable to case surveillance.

NIOSH Control Technology Support for Enhancing the Intervention Capacity of SENSOR States

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The NIOSH Division of Physical Sciences and Engineering (DPSE) has an ongoing research effort to document, evaluate, and disseminate information for preventing occupational illness. There are several areas in which there can be an effective synergism between DPSE control technology activities and SENSOR intervention activities, including: 1) SENSOR states often identify high hazard small businesses that require the development of new control technologies, such as lead in radiator repair shops; DPSE can help develop appropriate control technology, which can in turn be applied and disseminated by the SENSOR states; 2) DPSE has developed a technique of real-time video hazard analysis that allows more accurate definition of an intervention approach, and has trained a number of SENSOR states in its use; 3) SENSOR states are conducting a number of followback intervention site visits; DPSE has worked with several of the states to enhance the capacity to do this; 4) DPSE is helping compile and share intervention-oriented publications that have been developed by the OSHA 7(c)1 consultation programs, and these also will be shared with the SENSOR states.

Occupational Blood Exposures Among Emergency First Responders and Health Care Workers

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Health care providers are becoming increasingly aware and concerned about the transmission of bloodborne diseases such as HIV and Hepatitis B. Although the majority of providers work in traditional medical settings (hospitals and clinics), Oregon has nearly 10,000 emergency first responders (ambulance, fire and law enforcement) who respond to more than a quarter of a million EMS calls each year. A successful, multi-phase study was conducted in an effort to understand and quantify the occupational exposure experience of this comprehensive group of health care providers. The project addresses three questions: (1) Can Oregon's existing statewide anonymous HIV test reporting system be utilized to identify and document occupational blood exposures among health care providers, including emergency responders? (2) Do the occupational blood exposure policies and procedures of individual emergency response employers effect the number of incidents identified by the HIV test reporting system? (3) How does the self-reported blood exposure experience of a random sample of emergency responders compare with blood exposures identified through the HIV test

reporting system during the same period of time? Data describing the blood exposed workers, exposure type and circumstances, HIV and Hepatitis B status will be presented for the 1,254 exposure incidents that were identified. The work of a multi-disciplinary group that was formed to review study results and identify possible interventions will also be discussed.

The National Occupational Health Survey of Mining: North Carolina Results

Mark F. Greskevitch, J. M. Roman, C. A. Piacitelli, A. L. Dieffenbach, D. W. Groce, CDC, NIOSH, Morgantown, WV

The National Occupational Health Survey of Mining (NOHSM) was designed by the National Institute for Occupational Safety and Health (NIOSH) to characterize all of the health-related agents to which U.S. miners are potentially exposed. The NOHSM was mandated by the 1977 Federal Mine Safety and Health Amendments Act. While the NOHSM was designed as a nationwide survey, some parties have expressed interest in obtaining results on a state-by-state basis. One such request came from North Carolina.

NIOSH surveyed 22 currently active mines in North Carolina which were grouped into 10 mineral commodities. The North Carolina mines which NIOSH surveyed employed a total of 884 workers. the inventories listed 2,763 items, with 374 of those being zero use items. Three of the 22 surveyed mines claimed some information as trade secret. This presentation will summarize North Carolina vs. National results concerning the previously listed topics for each commodity plus employee potential exposures to chemical substances; trade name products; physical agents (noise, segmental and whole body vibration, and heat); musculoskeletal overloads; and welding-related processes.

Wisconsin's Surveillance of Occupational Back Injury through Workers' Compensation Reports

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Back injury is one of the most frequently occurring and serious forms of trauma which can happen in the work place. Workers Compensation (WC) data were analyzed to determine the scope of this problem in Wisconsin. Reports were selected from the WC case history file. Back injury risks were determined by age group and gender; industry-wide incidence rates and occupational odds ratios were calculated. For the years 1982-1988, over 123,000 back injuries were reported, accounting for over 25% of all compensation cases in Wisconsin. Cases increased from 15,000 in 1982 to over 21,000 in 1988. Males accounted for over 71% of the cases, while 56% of the reports were for workers aged 25-44. Work place back injuries have cost over 335 million dollars, while 1988 costs alone are projected to exceed $80 million dollars. High risk industries included motor freight and warehousing, primary metals, heavy construction, and health services. Occupations with elevated risk odds included freight handlers, shipping clerks, truck drivers, brick masons, nurses, and nursing aids.

Implementation of a Successful Physician-Based Reporting System for the Surveillance of Occupational Diseases

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With targeted mailings and a new ruling requiring occupational disease reporting by physicians, a successful occupational disease surveillance system was implemented in Ohio. While the reporting of occupational diseases has been required by state law for a number of years, there was little compliance to the requirement prior to the advent of SENSOR activities. Beginning in March 1989, physicians were systematically contacted regarding the reporting requirement. Initial communication was made with approximately 1,500 physicians who specialized in either occupational medicine, pulmonary medicine or radiology. The specialties were chosen because of the

SENSOR project focus on silicosis and lead poisoning. Communication has continued with this group via a quarterly newsletter, "Occupational Health Issues in Ohio". Additionally in late 1990, physicians specializing in family practice as well as occupational health nurses were added to the mailings.

In the fall of 1990 the number of diseases required to be reported was increased to nine and the reporting form was streamlined to facilitate completion of the form. The result has been a steady increase in the physician reporting pool that now includes approximately 150 providers. During 1990, 1,471 cases were reported from those providers including cases from 66 of Ohio's 88 counties.

Emergency Medical Technician (EMT) Risk of Exposure to Body Fluids

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Purpose: To identify the risk of exposure to patient body fluids for Emergency Medical Technicians (EMTs) providing pre-hospital emergency care. Setting: The City of Milwaukee, WI, has a population of 605,000. Its EMS system comprises fire engines for on-scene treatment (EMT-Eng), ambulances for transport of non-critical patients (EMT-Amb), and paramedic units for critical care (EMT-PM). Methods: For a two-week period in the spring of 1990, all EMS units in the city completed an "Encounter Form" after all emergency patient encounters recording availability of body fluids, procedures performed and any actual "exposure" to body fluids. An "exposure" was defined as any direct contact of a patient body fluid with an EMT's body, clothing, or protective garments. Results: During the two-week study period there were 2,805 patients with 4,014 total patient encounters (1.4 EMS units/patient). Study forms were submitted for 93% of all encounters. Blood was available for potential contact in 25% of patients. Other bloody fluids were available in an additional 1% and non-bloody fluids in 10% of patients. Of the 2,805 patients, 548 (20%) were the source of an exposure. There were 1,419 exposures to 1,161 EMTs. The percent of EMTs that were exposed while interacting with a patient was 10% for an EMT-Amb, 15% for an EMT-Eng, and 20% for an EMT-PM. The number of EMTs exposed per patient was 0.20 for an EMT-Amb, 0.45 for an EMT-Eng, and 0.66 for an EMT-PM. Seventy-four percent of exposures involved blood/bloody fluid. Hands were involved in 96% of exposures; in 94% of these cases the hand was gloved, but in 4% of the cases the glove was torn. Conclusions: EMTs are at significant potential risk for exposure to body fluids and attention to their protection is needed.

Wisconsin SENSOR Occupational Lead Exposure Surveillance

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In 1988, the Wisconsin Division of Health SENSOR program began surveillance on occupational lead exposures. Blood lead testing laboratories were contacted to explain reporting requirements: Wisconsin statutes require reporting when lead levels reach 25 micro grams per deciliter or above. A data base was written to obtain demographic information and to track multiple client contacts for proper handling of repeat lead monitoring reports. Since 1988, 4,676 reports on 1,562 clients have been logged into the database. Approximately 80% of the reports were between 25 and 39 micrograms per deciliter; 13% were between 40 and 49, while 7% of the reports were above 50. Only 5% of cases were female. The majority of reports have come from enameled iron manufacturing, storage battery manufacturing, and brass, bronze and copper foundries. To increase coverage of at-risk industries under - represented in the data base, radiator repair shops were targeted for intensive surveillance (walk through, air monitoring, free blood lead testing, lead standard compliance education). These radiator repair shop site visits were conducted in the city of Milwaukee.

The National Traumatic Occupational Fatalities Surveillance System

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The National Traumatic Occupational Fatalities (NTOF) surveillance system is compiled from death certificate information for persons aged 16 years or older with an external (injury or poisoning) cause of death and a positive response to the injury at work item. Certificates are collected from the 50 states, New York City, and the District of Columbia. The NIOSH Division of Safety Research automates the certificates submitted by the states. Several narrative fields including industry, occupation, injury description, and underlying, immediate and contributory causes of death are maintained in the data file. Additionally, industry and occupation codes are assigned to the cases. The data provides the unique opportunity to describe occupational injury deaths by state, industry, occupation, cause of death, and by demographic characteristics. Narrative fields allow searches of the data for categories of variables not accessible through coded data sets. The NTOF data are useful for identifying problem areas, targeting intervention strategies and evaluating progress toward reducing traumatic fatalities in the workplace. State-based analyses of occupational injury deaths could be enhanced through the utilization of information in the NTOF data base which allows state comparisons of occupational mortality rates by employment and cause of death.

Use of SENSOR to Identify New Allergens

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The use of SENSOR fosters physician and industrial hygienist coordination to ensure follow-up of targeted conditions such as occupational asthma. We report the potential for occupational exposure to asthmogenic agents in the pickle and pepper processing industry. Potential asthmagens include essential oils, oleoresins, sodium bisulfite, tartrazine and capsaicin (8-methyl-N-vanillyl-6-noneamide). Sensitization is dependent on the potency, allergenic properties and duration of exposure. Identification of potential occupational asthmagens was determined by literature search and review of available manufacturing data. Work-relatedness of symptomatology was determined in four employees employed at four separate processing plants. The diagnosis of occupational asthma was made by four separate physicians utilizing a recommended medical screening protocol for workers exposed to occupational allergens.

Occupational Injury Surveillance, Epidemiology and Control Activities in Colorado

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The Colorado Population-Based Occupational Injury Fatality and Surveillance system has tracked occupational deaths from 1982 to present using multiple reporting sources including the state vital records system and the state workers' compensation system. This basic methodology has been incorporated by the BLS as a national surveillance system - Census of Occupational Injury Fatalities. The Rural Occupational Injury Grant has sought risk factors to explain the five-fold rural/urban differences in occupational injury deaths in Colorado. Pre-event, event and post-event factors have been investigated. Surveillance has shifted from passive to active mode to enable case investigations of all non-transportation unintentional injury fatalities using the NIOSH Fatal Accident Circumstances and Epidemiology (FACE) protocol for fatalities not under OSHA jurisdiction. These active case investigations have augmented the surveillance system with more detailed information on injury circumstance, injury severity, trauma care and EMS response and employer characteristics.

Surveillance of Work-Related Carpal Tunnel Syndrome

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The California Occupational Health Program is working with the National Institute of Occupational Safety and Health to develop a model for occupational disease surveillance that links case reporting to worksite-specific preventive interventions (SENSOR). The California model builds on a small, but strategic corps of county-based primary care providers who actively report cases of carpal tunnel syndrome (CTS). Cases, co-workers, and employers are interviewed to gather data to confirm cases and prioritize worksite follow-up. Selected worksites are visited to provide additional information for case confirmation and to recommend worksite-specific preventions. The model also builds on significant outreach to leading institutions in the medical, business, labor, and governmental sectors. In 1989-1990, sixteen health care facilities in Santa Clara County reported 223 cases of CTS. Of 185 work-related cases, 30 were reported by three occupational health clinics, 28 from two physical therapy clinics, 13 from a neurologist, 71 from two hand surgeons, five from two chiropractors, and eight from union health care providers and 30 other providers. The cases were largely female (78%) and white (62%), though Latinos (24%) were a significant minority. Cases represented 84 different occupational (SOC) titles and 73 different four-digit industrial classifications (SIC). Cases involving clerical workers using VDTs, retail grocery check-out clerks, food manufacturing workers, and pharmaceutical packaging workers presented as clusters which were followed-up with worksite investigations. Model worksite intervention programs are being developed and evaluated for their efficacy to reduce risk factors for CTS.

Strategies for Prevention of Work-Related Pesticide Illnesses

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The California Occupational Health Program is working with the National Institute of Occupational Safety and Health to develop a model for occupational disease surveillance that links case reporting to worksite-specific preventive interventions (SENSOR). The California model builds on a small, but strategic corps of county-based primary care providers who actively report cases of work-related pesticide illnesses. Index cases, co-workers, and employers are interviewed to gather data to confirm cases and prioritize worksite follow-up. The model also builds on significant outreach to leading institutions in the medical, business, labor, governmental sectors and pest control advisors. In 1989-1990, over 185 cases were reported by 10 medical facilities in Fresno County and a dozen worksites were visited. At the worksites of index cases, risk factors for illness included a lack of effective safety training and supervision, faulty engineering controls, ineffective use of personal protective equipment, lax or nonexistent decontamination and medical surveillance, and the over-reliance on toxic pesticide use. Worksite specific recommendations were made to correct deficient pesticide health and safety programs. In 1990, specialists in integrated pest management (IPM) accompanied COHP staff on several pilot field investigations. IPM is a pest management philosophy in which pesticides are used only after alternative non-chemical methods have been implemented. The substitution of less or nontoxic alternatives has the potential to reduce or eliminate worker exposures. Growers were receptive to worksite visits that combined traditional occupational health and safety evaluations with IPM consultation.

Spanish Language Outreach Campaign to Improve Work-Surveillance of Related Carpal Tunnel Syndrome

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The California Occupational Health Program with assistance from the National Institute for Occupational Safety and Health has adopted an intensive community outreach strategy in the development of a provider-based

reporting and prevention system (SENSOR) for work-related carpal tunnel syndrome (CTS). This has included local and statewide outreach and education directed at the medical community, other government agencies, employers and trade associations, labor unions and other worker organizations and community groups.

Even with this attention to outreach, minority community members are often under-represented in traditional health surveillance systems. To study the relationship between targeted outreach to a "hard to reach" population of Spanish-speaking workers and their subsequent representation in our surveillance system, we have designed an outreach campaign to alert Spanish-speaking workers, who may be at high risk to CTS, to the potential risks in their jobs, early signs and symptoms of CTS, and how to get medical care for this condition. To accomplish this education and outreach, community based, local popular Spanish-language newspapers, and radio and television formats are being used to present our informational message. Selected health care facilities who are part of our SENSOR reporting network will participate in the outreach by being prepared to take calls from workers seeking more information, and to make appropriate referrals. An evaluation component will include a pre-/post-assessment of numbers of inquiries and referrals to the surveillance system.

Prevention of Work-Related Hospitalized Burns in Colorado

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The Colorado Department of Health (CDH) has developed a surveillance system designed to detect and prevent work-related hospitalized burns through funding from the National Institute for Occupational Safety and Health (NIOSH) Sentinel Event Notification System for Occupational Risk (SENSOR) program. The system allows CDH to link reports of burns with case followup and workplace intervention. Hospitals throughout the state report to the health department all burns that occur in Colorado and result in inpatient hospitalization. Between June 1989 and February 1991, 90 work-related hospitalized burns were reported to CDH. These reports were investigated through employee and employer interview, collection of relevant Worker's Compensation, OSHA, hospital, and other records, and worksite investigation of selected cases. The worksite investigation is authorized by regulation, and may be extended to other workplaces where similar exposure conditions exist. Primary, secondary, and basic causes of injury are determined. The results of the worksite investigation are summarized in a report that includes recommendations for remediation of identified problems. Case investigation reports are distributed to the employer, employee, union, trade association, and a number of safety organizations. Data from the hospitalized burn surveillance program are used to determine risk factors for burn injuries in the state.

A Cooperative Approach for Identification and Investigation of Occupational Fatalities in Colorado

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The Colorado Department of Health (CDH) has developed a surveillance system for non-transportation, unintentional occupational fatalities. CDH identifies fatalities through a notification network including cooperative agreements with the federal Occupational Safety and Health Administration (OSHA), Mine Safety and Health Administration (MSHA), and Colorado Workers Compensation system, CDH review of state death certificates and voluntary reporting of cases by state and local law enforcement agencies and county coroners. Response time and effectiveness of each notification source is evaluated. This notification network enabled CDH to identify and investigate 68 work related fatalities during the period of April 1989 to December 1990. CDH investigates fatalities using the Fatal Accident Circumstances and Epidemiology (FACE) protocol developed by the National Institute for Occupational Safety and Health (NIOSH) Division of Safety Research (DSR). Primary, secondary and basic causes of each fatal injury are determined by CDH. Secondary causes are further separated into hazardous practices and hazardous conditions. This information is grouped by industry type to develop industry-specific profiles. Each profile illustrates the common characteristics of fatal injuries within an industry and provides a method to enhance awareness within that industry. Company size, geographic location and severity of the initial injury have been found to be critical factors in Colorado

occupational fatalities. Case reports and profiles are distributed to employers, unions, trade associations, safety organizations, and other interested individuals. Complete copies of data and summary reports are transmitted to DSR, NIOSH.

State-Specific Respiratory Disease Mortality Surveillance of Agricultural Workers

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Death certificates represent a largely untapped resource for occupational mortality surveillance. We used national multiple-cause-of-death data to generate leads as to potential occupational respiratory disease problems in 14 states with industry and occupation information for each of the years 1985-1988.

Previous studies have shown agricultural workers to be at increased risk of developing respiratory diseases. However, most mortality studies have considered only crude mortality using underlying cause of death and may therefore underestimate the public health importance of contributing causes of death. Furthermore, crude mortality data is a poor measure of premature mortality in the working age population.

We utilized multiple-cause-of-death data to estimate the years of working life lost (YWLL, ages 20-64) for agricultural workers in each of the 14 states. Standardized rates for YWLL were derived across 11 respiratory disease categories using the 1980 Census to obtain estimates of the "population at risk".

Occupational mortality surveillance based on death certificates is particularly useful where cohort studies may be difficult. This applies to occupational groups in agriculture where small non-unionized work units are commonplace. However, inaccuracies in death certificate occupation and industry statements and inability to control for confounding variables such as smoking suggest that results should be interpreted with care.

Successful Follow-Back of Silicosis: Three Case Studies

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The largest number of silicosis cases in New Jersey exist in the sand mining and processing, foundry, and pottery (sanitary were) industries. Early in 1988, an informal working agreement was established between the New Jersey Department of Health and the NIOSH Division of Engineering and Physical Sciences, to conduct a comprehensive study in one facility in each of these industries. Studies were performed to develop specific control recommendations for each facility and to provide training in survey techniques and in the application of engineering controls for state personnel. These studies found that about 50% of the pottery workers, 33% of the foundry workers, and none of the sand mine workers were overexposed to silica. Other exposure hazards were also identified. Material handling operations were found to be a major source of potential silica exposure in all three plants. Recommendations for exposure reduction included: substitution of non-silica materials where possible, improvements in existing ventilation, and automation of material handling tasks. Follow-up visits indicated good compliance with the recommendations. These case reports demonstrate the value of active surveillance in silicosis prevention and the value of state/federal cooperation.

An Examination of Trends in Occupational Medicine Practices and Worker Access to Health Care

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NIOSH national surveys of the workplace conducted in 1972 and 1981 indicate considerable change in both the manner in which occupational medicine services are delivered to the workforce and in the traditional role of the occupational health physician. Trend analysis indicates that, as a whole, the workforce in the manufacturing

sector is being provided with increasing access to medical care as a consequence of employment. There is a parallel trend to provide these services off-site, primarily through contractual sources. There also appears to be a tendency to eliminate the traditional on-site occupational medicine physician in favor of contractual sources of care. Since the NIOSH data indicates that on-site provision of physician services in both small and large industrial facilities appears to be more comprehensive and to be provided more frequently, there is some concern about the ultimate effect on the health of the workforce.

Occupational Exposures and Mortality Among U.S. Construction Workers 1984-86: Filling in the Gaps

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Construction is one of the largest industries in the United States and employs 7.5 million workers. There is evidence indicating that construction special trades workers may be experiencing a high proportion of work-related injuries, but not much is known about health. This has led to an effort to explore the health problems of construction workers. As a first step, we analyzed the 1984-1986 NIOSH occupational mortality surveillance data. This is occupation-coded death certificate data from 19 U.S. states that together with the National Center for Health Statistics and the National Cancer Institute have shared the added costs of coding occupation and industry on their death certificates. Results show that several site-specific cancers and other chronic disease PMRs were statistically significantly elevated for 61,682 white male construction workers. Men younger than age 65, who were probably still employed at death had significantly elevated PMRs for cancer, asbestos-related diseases, mental disorders, alcoholism, digestive diseases, falls, poisonings, industrial fatalities and homicides. Statistically significant elevated PMRs were observed for men in several construction trades. NIOSH environmental data sets indicated that there were many potentially hazardous exposures at construction worksites. The data suggested several hypotheses for future in-depth research as well as some new NIOSH surveillance Branch projects for construction workers.

Minimum Specifications for Occupational Health Surveillance - Workplace Followup of Occupational Disease Reports

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It has been recommended that State Health Departments conduct surveillance for occupational disease. In addition to monitoring trends, these reports, as with communicable disease, can be used to initiate public health investigations. Data will be presented on the workplace investigations of 300 patients with silicosis and 100 patients with asthma. The outcome of workplace investigations initiated by disease surveillance will be compared with investigations initiated by employee generated complaints.

Although it is not financially or legally feasible to include routine workplace followup as minimum activity at a State Health Department, it is important to show whether or not routine followup of an occupational disease report is useful. The data that will be presented on the efficacy of workplace investigations comes from OSHA inspections conducted by the Michigan Department of Public Health. Since referrals to OSHA are an important referral pattern used by State Health Departments, the results that will be presented are potentially generalizable to other states.

Targeting Health Promotion Using Occupationally Coded Mortality Data

Carol Hogfoss Rubin, C. A. Burnett, W. Halperin, P. Seligman, CDC, NIOSH, Cincinnati, OH

Twenty-three states have contributed to an occupationally coded mortality data set. We evaluated this data in terms of its utility in identifying groups of workers who are at greater risk of nonoccupational diseases and therefore may benefit from targeted prevention. 2.9 million occupationally coded death certificates collected between 1979 and 1987 were used to calculate Proportionate Mortality Ratios (PMRs) for a series of preventable diseases. Ten causes of preventable death e.g., breast cancer, cervical cancer and ischemic heart disease, were analyzed and groups of workers with elevated PMRs described. Each disease exhibited a distinctive pattern of variation by occupational grouping. For example, there is an elevated risk of breast cancer among teachers (PMR=164), whereas this group exhibits a low risk of cervical cancer (PMR=76). We conclude that prevention of disease in the workplace must have occupationally induced illness as its primary focus but should also use occupation to target and reach populations that will benefit from disease prevention programs.

Closing the Loop: How Surveillance and Intervention Activities Complement Each Other in Occupational Disease Prevention and Control

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This paper reviews California occupational disease surveillance programs (lead poisoning, pesticide illness, carpal tunnel syndrome), and discusses the interactions between surveillance and intervention activities. For example, a survey of lead-using employers indicated that only a tiny fraction of lead-exposed workers were receiving blood-lead monitoring. On-site evaluations in fifty lead-using companies in Los Angeles County verified wide variations among different industries with regard to lead poisoning prevention practices. A laboratory-based lead registry showed very few case reports from industries with low prevalences of blood-lead monitoring. A multi-faceted program designed to reduce lead poisoning in the radiator repair industry focused initially on efforts to ensure blood lead screening in radiator repair workers, to make this industry accessible to the existing surveillance system. Registry case reports for radiator workers increased about eight-fold in one-year period.

Parental Occupational Lead Exposure and Childhood Blood Lead Levels

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Numerous studies have documented that children of lead workers are at increased risk of secondary exposure to lead. Blood lead levels as low as 10-15 micrograms per deciliter of whole blood have been associated with neurobehavioral deficits in young children and fetuses. Studies of lead workers and their children have found a large number of cases where the children have blood lead levels above 30 mcg/dl. This study examined whether there was a relationship between blood lead levels for workers and their children from the battery manufacturing and battery recycling industries in Texas. Data analysis was limited to 229 workers and household members who met the case definition of the study. Although no correlation was found between the worker's blood lead levels and that of their children, 30% of the children tested had blood lead levels 15 mcg/dl or greater. A statistically significant difference was noted when comparing children's mean blood lead levels by type of industry. Children, whose parents worked in battery recycling, had a mean lead level of 21.5 mcg/dl compared to mean lead levels of 9.9 and 12 mcg/dl among children whose parents who worked in battery manufacturing. A significant decline was also noted in blood lead levels as age increased. Mean blood lead levels did not vary significantly according to other exposure opportunities.

Hazard Surveillance for the 1970's, 1980's, and the Future

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NIOSH researchers have conducted two major nationwide surveys as part of a hazard surveillance program. The first survey, known as the National Occupational Hazard Survey (NOHS), was conducted in 1972-1974. The second survey, known as the National Occupational Exposure Survey (NOES), was conducted in 1981-1983. The Cooperative Exposure Survey (CES) is on the drawing board. The CES is a multiphase program to illicit voluntary cooperation from employees and to identify and inventory hazardous agents in their facility. Data are presented which describe and demonstrate the utility of the two national surveys and the CES from a state and local occupational health and safety perspective. Several hypotheses are generated that may have application for hazard surveillance in the future. The NOHS and the NOES could be valuable reference or base-line data sources, while the CES could serve as an early warning system or as a locator resource, or as a supplement to data gained from other sources. Several computer-generated maps are presented that identify geographic areas where trends in potential exposures to selected agents are most dramatic.

Establishment of a State-Based FACE Project in the New Jersey Department of Health

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The Occupational Health Service in the New Jersey Department of Health (NJDOH) has established a Fatal Accident Circumstances and Epidemiology (FACE) project based on the NIOSH FACE protocol. The purpose of FACE is to conduct in-depth investigations of specific types of workplace fatalities and to make recommendations for their prevention. The FACE project was facilitated by our on-going fatal injury surveillance database which indicated the number and type of expected fatalities per month. Inter-agency cooperation between the NJDOH and federal OSHA was achieved after confidentiality issues were resolved. County-based medical examiners and OSHA Area Directors have reported cases to us. The NJDOH FACE investigators conduct joint on-site investigations with OSHA of the causes and contributing factors of fatal occupational falls and electrocutions. The methods and results of the first 15 investigations will be discussed. Two investigations will be described in detail. The future plans of our project include continuing investigation of workplace fatalities with possible expansion to confined space fatalities and wide dissemination of results of investigations to prevent the occurrence of similar injury events.

Minimum Specifications for Occupational Health Surveillance: Surveillance Utilizing Hospital Discharge Records

Martha J. Stanbury, H. Fonius, New Jersey Department of Health, Trenton, NJ

In this report it is recommended that minimum specifications for state health department based occupational health surveillance include the utilization of hospital discharge data for trend monitoring and sentinel event surveillance. The inherently occupational diseases such as pneumoconioses and certain acute lung conditions are identifiable by IOD code. Although personal identifiers usually are not available, trend monitoring can be accomplished by eliminating repeat admissions through matching on demographic variables. Simple extrapolations from these data can be used to make estimates of disease in the non-hospitalized population. When personal identifiers can be obtained, either voluntarily from hospitals or by implementing a hospital reporting regulation, these data are useful for index case identification and follow-up, using the SENSOR model of occupational disease surveillance. These and other applications of hospital discharge data for occupational health surveillance will be presented.

Development of Nationally Standardized Occupation and Industry Coding Software

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Surveillance of occupational injuries and diseases requires accurate categorization of occupations in industry (O/I) information to characterize work injuries and illnesses. Narrative O/I entries on vital records are often manually coded into standardized employment categories as part of state-based surveillance activities. Although some state and federal agencies have independently developed O/I coding software to meet their specific requirements, there is a need for a nationally standardized software that is accurate, efficient, and applicable to a broad range of users. Availability of such software to states would allow for cost effective O/I coding and provide data comparability by state. In a collaboration with NCHS, AVRHS, and CDHS, NIOSH sponsored a feasibility study and alternatives analysis for developing such software. The process and results of this study are presented and the next steps in the development of nationally standardized O/I coding software are discussed.

Occupational Fatality Surveillance in Massachusetts

Lynn Taylor, L. Davis, Massachusetts Department of Public Health, Boston, MA

A comprehensive traumatic occupational fatality system should accomplish two goals. It should: 1) rapidly identify individual traumatic occupational deaths so that prompt workplace investigations can be carried out; and 2) document overall patterns of traumatic occupational fatalities to both target and evaluate prevention efforts. The MA traumatic occupational fatality system is designed to accomplish both of these goals. It includes a 24-hour occupational fatality hotline, in-depth investigations of selected fatalities (conducted as part of the national Fatal Circumstances and Epidemiology (FACE) Project, and annual analysis and dissemination of traumatic occupational fatality data collected from multiple sources. Our experience with the hotline and in conducting FACE investigations will be described, and recent summary findings reviewed.

Private Industry Compliance with New Jersey's Silicosis Surveillance Program

David J. Valiante, P. Bost, M. Stanbury, New Jersey Department of Health, Trenton, NJ

The New Jersey Department of Health (NJDOH) has maintained a register of silicosis cases using records, starting in 1979. To date 737 cases have been reported, of which 177 have been confirmed based on interview, medical records, and X-ray data. The NJDOH conducted 54 workplace inspections as the result of reports of silicosis. The inspection consisted of employer and employee interviews, a plant walkthrough and a report with recommendations aimed at preventing exposure to silica dust. Company compliance with these recommendations is strictly voluntary.

NJDOH evaluated company compliance with our recommendations through follow-up inspections at 15 companies. A total of 136 recommendations were issued to these companies during the original inspections between 1986 and 1990. We found that approximately half of the recommendations were fully or partly implemented. Compliance with NJDOH recommendations will be presented by industry type, by hazard category, and by recommendation type. The significance of these findings for silicosis surveillance using the SENSOR model will be discussed.

Evaluation of Potential Work-Related Exposure to Blood and HIV Among Denver Police Officers

Richard E. Hoffman, N. Henderson, K. O'Keefe, Colorado Department of Health, Denver, CO

Colorado law explicitly authorizes state and local health departments to provide evaluation of public safety workers who have occupational exposure to blood and bodily fluids potentially infectious with HIV. The evaluation may consist of accessing medical and laboratory records of the source person or requiring HIV antibody testing of the source person. Since December 1989, the Colorado Department of Health has conducted active surveillance for exposures among Denver Police Department officers. In the first 14 months, 125 incidents were reported among approximately 1,200 officers. The type of incident most frequently reported was exposure to saliva from biting or spitting; these were judged to have negligible risk of HIV transmission. In 30 incidents, there was significant exposure to blood; in 5 (17%) of these, the source person was determined to have HIV infection. No seroconversions in exposed police officers have been documented. The seropositivity rate of source persons involved in blood exposures is considerable higher than the overall rate and the rate among intravenous drug users who voluntarily seek HIV antibody testing at public counseling and testing sites in Denver.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1993: 750-160/80004

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