VIII. Injury Surveillance

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Introduction

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

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

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

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

Concepts for Epidemiology and Surveillance of Occupational Injury

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

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

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

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

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

Existing Databases That Present Surveillance Opportunities

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

Demographic/Denominator Datasets

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

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

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

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

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

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

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

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

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

Health Outcome Databases

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Hazards/Causal Factors

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

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

Detection/Monitoring Strategies

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

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

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

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

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

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

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

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

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

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

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

Intervention Strategies

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

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

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

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

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

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

Summary and Recommendations

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

Denominators

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

Hazard Monitoring

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

Injury Process/Event Coding

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

Reporting of Health Outcomes

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

Fatality Monitoring

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

Injury Epidemiologic Modeling/Causal Factors Analysis

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

Intervention Strategies and Evaluation

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

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