Occupational Injury Prevention

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— Contributors—

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Where We Are

Occupational injuries are an important part of the injury problem in the United States, although recently they have generally been given less attention by public health professionals than injuries that occur in other settings, such as the home, the highway, or recreational settings. There are widely divergent estimates of the absolute numbers and rates of fatal and nonfatal work-related injuries with some of the reasons for the discrepancies being variations in definitions, worker populations included, methods of case ascertainment, and data sources (1). The current picture provided by occupational injury statistics reflects the limited use in the past of epidemiologic principles and the lack of a public health approach in addressing the occupational injury problem (2).

A work-related injury is one that is attributable to work activities arising directly out of and in the course of employment. Work activities are those duties or tasks that produce a product or result, or are done in exchange for money, goods, services, profit, or advantage. In some countries, such as Australia, injuries of bystanders resulting from the actions of others at work are considered work-related. In some countries, injuries occurring during a worker's commute to or from work are considered occupational injuries. There is currently no standard definition of work-related injury in this country; however, how it is defined affects surveillance and research as well as prevention strategies.

Dimension of the Problem

On the day that 7 crew members were killed in the explosion of the space shuttle Challenger, at least 16 other U.S. workers were also killed at work, and thousands more were injured. However, only the seven who died on the space shuttle received the attention of the media and a stunned public. This contrast illustrates the lack of media attention and public concern bestowed on workers who die or are disabled as a result of occupational injury, possibly because their injuries or deaths are not so spectacular, but possibly because the risk of injury may be perceived as an acceptable risk of working. However, occupational injuries should not be regarded as inherent in the workplace, nor should they be acceptable.

Occupational injury is an enormous and costly problem. Most incidents resulting in worker injuries are preventable and could be averted if known prevention strategies were more widely implemented. Until the public recognizes the importance of occupational injuries and demands safe work environments — and is supported in these demands by government, employers, and workers — reasonable protection of all workers will not be ensured.

The most effective interventions to date for reducing injuries have been those involving engineering, biomechanics, and environmental designs, the mainstays of the safety science approach to injury prevention. However, the potential for reducing work-related injury through these efforts is greatly enhanced when epidemiologic techniques are used to identify risk factors and evaluate preventive strategies and programs. Crucial to the process of solving occupational injury problems is interdisciplinary action, which spans the range from identification to widespread implementation of effective preventive strategies and requires the collaborative efforts of managers, workers, researchers, planners, and support staff from a variety of organizations and disciplines. Government, industry, labor, universities, workers, and the public must focus attention on this problem and coordinate their efforts toward effective injury prevention in the workplace.

In addition to the necessary research conducted in universities and implementation of prevention strategies in worksites, the public needs to be informed and convinced of the importance of work-related injury. Private and public organizations involved in occupational injury surveillance, research, and prevention activities should develop ways to communicate risk information using the latest information about crafting risk messages and reaching intended audiences, available dissemination channels, and the variety of potential media. Broadcast and print media, which have influenced public awareness of other public health problems and risk areas, have yet to fully convey the importance of occupational injury as a significant public health problem.

The future workers of our country should not wait until they enter the work force to learn about prevention of injuries. Just as preventive health-related information, such as information on the importance of exercise and nutrition, has been stressed in school curricula from elementary schools through universities, information on injury and injury prevention concepts could conceivably be introduced in elementary school science curricula and most certainly in secondary school science, industrial arts, and vocational-technical programs. Programs aimed at incorporating occupational safety and health components in the curricula of university engineering and medical schools are under way.

Finally, because of the close interaction between home and the workplace, interventions implemented in the workplace, even though they target workers, also provide an avenue for reaching workers' families. Many of the principles of injury prevention applicable in work settings are also applicable outside the workplace. However, the workplace provides a unique opportunity to implement, monitor, and demonstrate the effectiveness of many prevention strategies that are difficult to implement and evaluate elsewhere. Employers can design or modify jobs or processes, enforce the implementation of specific rules and procedures, provide and require the use of protective equipment, develop and provide specialized training, and otherwise structure and control the workplace environment to reduce injuries. In the absence of voluntary employer action, government regulators, corporate policymakers, insurers, unions, and other employee advocates can exert pressure on employers to reduce injuries through workplace management.

Ultimately, the goal of occupational injury control is the protection of workers, individually and in groups. The process of injury control, therefore, must involve workers and empower them to participate in the prevention of injuries.

There are varying estimates of the number of work-related injuries and deaths and much debate about their validity and importance. However, one thing is certain: these deaths and injuries — whatever the true number — are intolerable.

Despite the limitations, existing data indicate that the magnitude of occupational injury is staggering. Between 7,000 and 11,000 workers are fatally injured on the job each year (3,4). Every year about 7 of every 100 workers sustain nonfatal injuries while at work. In 1989 alone, almost two million workers sustained injuries that resulted in disability (4). The cost of occupational injury that same year was conservatively estimated at more than $48 billion (4). A more recent study by the RAND Corporation places the cost at over $83 billion for 1989 alone (5). Moreover, the pain, suffering, decreased quality of life, and stress associated with injury, as well as the financial cost to the worker, the family, and society are among the consequences of injury that are nearly impossible to measure (6).

Fatal Occupational Injury

The National Institute for Occupational Safety and Health (NIOSH), part of the Centers for Disease Control (CDC), uses the National Traumatic Occupational Fatality (NTOF) data base based on death certificates that indicated injury at work (7). The NTOF data for 1980 to 1985 indicate that about 7,000 work-injury fatalities occur in the United States each year (3). However, the validity of these data depend upon accurate and consistent cause-of-death identification and the consistent completion of a single variable on the death certificate. Because this reporting is not uniformly accurate and consistent, NTOF data undercount the number of occupation-related deaths. Table 1 shows the number of worker deaths within major industry groups associated with leading causes of death. These data cover 1980 through 1986. Table 2 shows the rate (per 100,000 workers) of deaths within major industry groups associated with leading causes of death for the same 7 years. Table 3 shows the number and rate (per 100,000 workers) of worker deaths from occupational injury by cause and sex for 1980 through 1985.

The National Safety Council (NSC) estimated that 10,400 work-related deaths occurred in 1989 (4). This estimate is based on deaths in a work force in excess of 114 million and reflects several reporting mechanisms long used by the NSC. The reporting sources for the National Safety Council include the National Center for Health Statistics, state vital statistics departments, and state industrial commissions, although the method for obtaining the NSC estimate is difficult to validate. The NSC estimate does not include worker deaths resulting from intentional injuries (homicides and suicides), a problem of recent concern.

Table 1
Traumatic Occupation-Related Fatalities By Leading Causes of Death* and Major Industry Group,**
U. S. Civilian Labor Force
(National Traumatic Occupational Fatality Data Base, 1980-1986)

	Total+	Agriculture/ Forestry/ Fish	Mining	Construction	Manufacturing	Transportation	Wholesale Trade	Retail Trade	Finance/ Insurance/ Real Estate	Service	Public Administration
Motor Vehicle (E810-E829,E846-E849)	9,865	789	285	957	675	3,752	308	417	91	629	577
Machinery (E919)	6,060	1,852	421	977	854	389	58	87	38	218	69
Homicide (E960-E969)++	5,344	152	24	212	300	481	129	1,756	134	795	502
Falls (E880-E888)	4,215	244	108	1,938	439	267	42	92	39	290	80
Electrocution (E925)	3,296	361	141	1,165	272	489	29	56	11	153	53
Struck by Falling Object (E916)	2,929	369	315	590	719	237	22	44	9	151	38
Air Transport (E840-E845)	1,844	131	33	61	94	630	16	32	49	193	390
Unknown/undet. (E980-E989, Blank)	1,555	164	55	197	191	262	19	108	13	125	87
Suicide (E950-E959)	1,297	89	10	99	111	76	17	197	46	290	84
Explosion (E923, E921)	1,246	39	159	152	271	113	12	46	2	104	31
Flying Object/Caught (E917-E918)	1,095	99	83	197	206	148	16	25	5	49	15
Other	1,057	102	23	130	204	103	11	66	10	90	104
Natural Environ. (E900-E909, E928)	1,038	248	96	158	133	85	11	21	5	67	31
Water Transport (E830-E838)	888	288	14	45	29	167	9	42	1	51	54
Suffocation (E911-E913)	864	95	57	332	79	57	9	15	5	35	17
Fire (E890-E899)	829	64	56	99	164	48	14	46	6	92	55
Poisoning (E850-E858, E860-E869)	696	58	57	72	114	67	11	28	5	86	25
Drowning (E910)	647	116	29	86	44	70	4	10	3	96	41
Rail Transport (E800-E807)	324	4	8	15	18	245	1	2	2	4	2
Total	45,089	5,264	1,974	7,482	4,917	7,686	738	3,090	474	3,518	2,255

* International Classification of Diseases, Ninth Revision - Supplementary Classification of External Causes of Injury and Poisoning.
** Standard Industrial Classification Manual, 1987.
\+ Totals include cases for which industry could not be classified (17%).
++ Homicide data for New York, Oklahoma, Louisiana and Nebraska were not available.
Shading denotes the three leading causes of death in each industry group.

Table 2
Traumatic Occupational Fatality Rates (per 100,000 workers) By Leading Causes of Death* and Major Industry Group,
U. S. Civilian Labor Force
(National Traumatic Occupational Fatality Data Base, 1980-1986)

	Total+	Agriculture/ Forestry/ Fish	Mining	Construction	Manufacturing	Transportation	Whosesale Trade	Retail Trade	Finance Insurance RealEstate	Service	Public Administration
Motor Vehicle (E810-E829, E846-E849)	1.65	3.04	4.05	3.21	0.49	11.44	0.82	0.38	0.23	0.46	1.64
Machinery (E919)	1.01	7.14	5.99	3.28	0.62	1.19	0.15	0.08	0.10	0.16	0.20
Homicide (E960-E969)++	0.89	0.59	0.34	0.71	0.22	1.47	0.34	1.58	0.34	0.58	1.43
Falls (E880-E888)	0.70	0.94	1.54	6.51	0.32	0.81	0.11	0.08	0.10	0.21	0.23
Electrocution (E925)	0.55	1.39	2.01	3.91	0.20	1.49	0.08	0.05	0.03	0.11	0.15
Struck by Falling Object (E916)	0.49	1.42	4.48	1.98	0.52	0.72	0.06	0.04	0.02	0.11	0.11
Air Transport (E840-E845)	0.31	0.51	0.47	0.20	0.07	1.92	0.04	0.03	0.12	0.14	1.11
Unknown/undet. (E980-E989, Blank)	0.26	0.63	0.78	0.66	0.14	0.80	0.05	0.10	0.03	0.09	0.25
Suicide (E950-E959)	0.22	0.34	0.14	0.33	0.08	0.23	0.05	0.18	0.12	0.21	0.24
Explosion (E923, E921)	0.21	0.15	2.26	0.51	0.20	0.34	0.03	0.04	0.01	0.08	0.09
Flying Object/Caught (E917-E918)	0.18	0.38	1.18	0.66	0.15	0.45	0.04	0.02	0.01	0.04	0.04
Other	0.18	0.39	0.33	0.44	0.15	0.31	0.03	0.06	0.03	0.07	0.29
Natural/Environ. (E900-E909, E928)	0.17	0.96	1.37	0.53	0.10	0.26	0.03	0.02	0.01	0.05	0.09
Water Transport (E830-E838)	0.15	1.11	0.20	0.15	0.02	0.51	0.02	0.04	0.003	0.04	0.15
Suffocation (E911-E913)	0.14	0.37	0.81	1.11	0.06	0.17	0.02	0.01	0.01	0.03	0.05
Fire (E890-E899)	0.14	0.25	0.80	0.33	0.12	0.15	0.04	0.04	0.02	0.07	0.16
Poisoning (E850-E858, E860-E869)	0.12	0.22	0.81	0.24	0.08	0.20	0.03	0.03	0.01	0.06	0.07
Drowning (E910)	0.11	0.45	0.41	0.29	0.03	0.21	0.01	0.01	0.01	0.07	0.12
Rail Transport (E800-E807)	0.05	0.02	0.11	0.05	0.01	0.75	0.003	0.002	0.01	0.003	0.006
Total	7.54	20.30	28.08	25.13	3.58	23.44	1.96	2.78	1.19	2.56	6.41

* International Classification of Diseases, Ninth Revision - Supplementary Classification of External Causes of Injury and Poisoning.
** Standard Industrial Classification Manual, 1987.
\+ Totals include cases for which industry could not be classified (17%).
++ Homicide data for New York, Oklahoma, Louisiana and Nebraska were not available.
Shading denotes the three leading causes of death in each industry group.

In 1989, the Bureau of Labor Statistics (BLS), which excludes public sector employees, the self-employed, and employees of companies with fewer than 11 workers, reported about 3,300 deaths in the population of workers that it surveys (6). The BLS estimate is based on a survey sample of approximately 280,000 individual employers, with a 94% response rate. In addition to omitting many groups of workers, the BLS sampling scheme results in estimates that tend to disproportionately reflect the experience of large companies. Fatality estimates are made on the basis of data from establishments with 11 or more employees only. As discussed in the report by the National Academy of Sciences (9), the BLS greatly undercounts occupational deaths.

Nonfatal Occupational Injury

Limited data are available on the frequency of nonfatal work-related injuries, and no data are available on work-related injuries requiring hospitalization. The BLS estimated that about 6.4 million injuries (7 per 100 full-time workers) occurred during 1988 (10). The estimate includes recordable injuries (including deaths), injuries resulting in days away from work or restricted activity, and injuries without lost workdays. According to the estimate, nearly 2.9 million injuries resulted in lost workdays. A report sponsored by the National Academy of Sciences (9) concluded that there was considerable underreporting in the BLS annual survey. Another source of nonfatal occupational injury data is based on a sample of approximately 66 emergency rooms from the Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS), which collected data for the National Institute of Occupational Safety and Health (NIOSH) during 1981-1986. The authors of an unpublished NIOSH study based on this sample estimated that over 3.8 million occupational injuries of varying severity and outcome are treated every year in U.S. emergency departments. Because this estimate is an extrapolation, the true number may be much higher. The NSC defines a disabling injury as one that causes death, permanent disability, or any degree of temporary total functional disability beyond the day of the injury. The NSC also estimates that there were 1,700,000 disabling injuries in 1989 among workers in the United States (4).

Lost Workday Rates

Estimates of lost workdays depend on the data source used to count injuries. The National Safety Council estimates days lost from injuries during 1989 to be 75 million, which includes those lost because of injuries that occurred in 1989, as well as in previous years (4). According to the Bureau of Labor Statistics, among the nearly 3.0 million injuries in 1989 that resulted in lost workdays, the average lost workdays per case was 20, or a total of 60 million lost workdays in the population of workers that BLS reports on (10). Although the number of lost workdays is used as a criterion for reporting injuries or as a proxy for severity, such uses may be misleading because of the employer's incentive to return injured workers to the workplace to avoid "reportable" injuries, even if they cannot perform their usual tasks.

Table 3
Deaths and Death Rates from Occupational Injury, by Cause and Sex, 1980-1985

Cause	Male		Female		Total	
	Deaths	Rate*	Deaths	Rate*	Deaths	Rate*
Motor vehicle, traffic	6,809	1.99	493	0.19	7,302**	1.20
Motor vehicle, nontraffic	768	0.22	31	0.01	799	0.13
Aviation	1,480	0.43	78	0.03	1,558	0.26
Railway	262	0.08	4	0.00	266	0.04
Water transport	583	0.17	11	0.00	594	0.10
Drownings/suffocation	1,202	0.35	38	0.01	1,240	0.20
Poisonings	493	0.14	7	0.00	500	0.08
Falls	3,378	0.99	113	0.04	3,491	0.57
Fire and Flames	627	0.18	55	0.02	582	0.11
Firearm	181	0.05	12	0.00	193	0.03
Natural/Environmental factor	394	0.12	30	0.01	424	0.07
Falling object	2,342	0.68	19	0.01	2,361	0.39
Struck against	531	0.16	10	0.00	541	0.09
Caught in/between	333	0.10	9	0.00	342	0.06
Machinery	4,950	1.45	93	0.03	5,043	0.83
Explosive	770	0.22	44	0.02	814	0.13
Explosion of pressure vessel	212	0.05	5	0.00	217	0.04
Electric current	2,695	0.79	15	0.01	2,710	0.45
Suicide	1,017	0.30	113	0.04	1,130	0.19
Homicide	3,586	1.05	861	0.32	4,447	0.73
Other and unspecified	1,445	0.42	111	0.04	1,556	0.26
TOTAL	34,058	9.94	2,152	0.81	36,210	5.95

Source: Injury Fact Book, 2nd Ed. (8).

*Per 100,000

**Data from the Fatal Accident Reporting System (FARS) maintained by the U.S. Department of Transportation indicate that there may be as many as 3,000 deaths per year resulting from occupational motor-vehicle crashes, rather than the approximately 1,200 per year indicated here (8).

Costs: Economic Impact of the Problem

The costs of occupational injuries go well beyond the financial burden of medical treatment. Pain, suffering, altered quality of life, stress and its resulting illnesses, together with loss of earning power are among the consequences of injury that are nearly impossible to quantify (6,11). Furthermore, the effects of an injury spread to other individuals with whom the seriously injured person and his or her family interact, compounding the problem of determining the cost of work-related injury.

Even economic costs are not easily tabulated. One recent report to Congress (12) identified the costs of injury by major cause but did not include data on the total economic burden of occupational injury because such data are not available. Similarly, insurance administration costs associated with workers' compensation and product liability are not easily identified, nor are long-term morbidity costs, including the costs of follow-up health care, residential care, legal assistance, and property damage. Productivity losses associated with disabling injury include losses related to production disruption, equipment and property damage, the selection and training of replacement workers, and injury investigation.

The NSC estimated that the overall cost of work-related injuries incurred in 1989 was more than $48 billion. This is an underestimate of the actual cost for several reasons, including underreporting of injuries (6,13), the exclusion of intentional injuries (14-16), and the fact that neither children less than 14 years of age nor workers often not included under traditional compensation programs (e.g., the self-employed and public sector workers) were not considered. People operating small family farms, who constitute a large proportion of all farm workers in many states, are one important population of workers not universally covered (17).

A recent unpublished study* reported estimates of over $21 billion (based on 1989 dollars) spent annually for medical care, lost productivity, and administrative processing of work-related injuries. The authors state that this should be considered only part of the total cost for all work-related injuries because it does not include fatal injuries (which they report to be about 11,000 per year) or those injuries that did not result in at least 3 lost workdays (over 9 million per year). Another report put the cost at over $83 billion dollars for the same year (5).

Considering the enormous cost to society (and industry) that occupational injury imposes, cost-benefit studies of injury prevention programs can help illustrate the savings associated with injury prevention. In the petroleum industry, the introduction of equipment that permitted automatic connection and disconnection of pipes (without worker involvement) on offshore drilling rigs resulted in significant decreases in injuries and paid for itself within 6 years (18).

*Rossman SB, Miller TR, Douglass JB. The costs of occupational traumaic and cumulative injuries. Research supported by the National Institute for Occupational Safety and Health, Centers for Disease Control. (CDC Grant No. R49/CCR 303675-02) March 1991.

International Perspective

There is considerable variation among nations in the numbers, rates, severity, and external causes of occupational injuries. In its Year Book of Labor Statistics, the International Labor Organization (Geneva) publishes tables of the numbers of work injuries and the rates of fatal occupational injuries by industry for many countries. In most countries, however, injury statistics are compiled as a by-product of administrative work processes and labor regulations. The definitions, coverage, and methods used to compile these data vary so widely from nation to nation that comparisons are difficult. However, many countries have developed injury prevention strategies that represent a valuable source of information and data for programs for injury prevention.

A few developed countries (such as Sweden) have comprehensive surveillance systems or registries to identify and monitor work-related injuries and fatalities nationwide for the specific purpose of developing injury prevention strategies and policies. In developing countries, most of the labor force works in environments that have minimal or no safety standards. Because of the overall poor socioeconomic status of these countries and because of their efforts to industrialize rapidly, governments, companies, and even workers may compromise safety. The risk of being injured at work is likely to be greater in less technologically advanced environments where safety measures are often sacrificed in hopes of increasing productivity and saving money. Of course, risk for injury may increase as a function of production pressures in technologically advanced environments as well.

Comparisons among geographic or economic sectors afford the opportunity to share experiences and information on effective injury prevention programs. In Sweden, in response to an observation that injuries caused by chain saws occurred frequently, modifications were developed in the 1960s to make chain saws safer. This is in contrast to the United States where responsibility at the federal level for occupational safety was not recognized until the passing of the Federal Coal Mine Health and Safety Act in 1969 and the Occupational Safety and Health Act (OSH Act) in 1970. Examining these differences relating to national policy may uncover important new prevention strategies or verify the effectiveness of certain current prevention programs. Finally, the low occupational-injury rates in some countries give hope that, if the problem of occupational injuries is approached properly, rates may be lowered in this country also.

Commitment to the Goal: Preventing Occupational Injury

The United States has yet to organize and coordinate a successful, multidisciplinary, multiorganizational approach to preventing occupational injury. Collaborative efforts are essential to improve research and more effectively implement interventions (19).

Unfortunately, funds for research and training programs are scarce. The dearth of people well-trained in injury epidemiology and safety engineering is a major problem. The resources available for occupational injury prevention and control in the United States pale in comparison with those available in western Europe. For example, agencies involved in occupational safety and health in Finland and Sweden have budgets (per worker) almost 20 times that of NIOSH (19).

Occupational injury prevention is linked to organizational commitment to workplace safety. Employers, employees, and others responsible for or interested in protecting workers should know and understand the risks workers face and how to reduce or eliminate those risks. Just as systematic methods are employed in identifying risk through surveillance and in developing preventive strategies, systematic methods can and should be employed in communicating information on risk and injury prevention.

The results of studies have demonstrated that not only does management commitment to safety decrease the number of work-related injuries, it is also cost-effective. Therefore, to improve occupational safety and health in the 1990s, senior company executive involvement is necessary (20). The John Deere Company, for example, attributes a 74% decrease in their OSHA-recordable injury rate from 1975 to 1984 to the establishment of facility-based occupational health and safety goals supported by management (21). Other examples include an automobile parts manufacturing company that, after implementing material handling procedures in 1986, experienced a 73% reduction in annual injury-related worker compensation claims compared with 1985 (22).

The link between injury prevention and improved quality and increased productivity needs to be explored and documented, because proof of this relationship will strengthen organizational commitment to workplace safety. Within the context of a production process, the occurrence of an injury is typically the culmination of a series of events beginning with some variation in the process. Once these events happen, the occurrence of an injury is predictable within a broad time frame, but its actual occurrence at a given time or during a particular shift is not predictable, and the injury is typically (and incorrectly) seen as a random event. Considered in this perspective, the consistent production of a high-quality product is incompatible with a high rate of injuries.

Commitment to workplace safety within an organization should result in workplace design factors being considered in the bidding specifications for the equipment that will be purchased or constructed for the production process. For example, the purchasing agent must realize that the specifications related to safety features cannot be negotiated away for a lower price or faster delivery schedule. For existing operations, process reviews should involve a team approach (engineering, quality, and safety) with input from operators who have actually been running the process. Construction contracts should have an injury prevention component built into the contract bid process in the same way financial stability

is included. Potential bidders should be required to demonstrate a low rate of injuries among their workers, sufficient injury-prevention activities, and compliance with safety standards, or they should be eliminated from the bidding process.

Labor-management agreements are also important for promoting workplace safety. These relationships are governed by collective bargaining contracts and regulatory and labor relations statutes, which create important rights and responsibilities. Workplace safety is a common feature of labor-management contracts, which often provide for health and safety committees. Many national and international unions also have their own programs and staff for promoting workplace safety.

Surveillance Issues

The need for developing injury surveillance systems and using epidemiologic data as the basis for targeting and developing prevention strategies is clearly stated in *Injury in America* (23). Carefully designed surveillance of occupational injuries and fatalities is essential not only to document accurately the magnitude of the injury problem and identify potential risk factors, but also to target interventions and to evaluate the effectiveness of specific programs and interventions (24,25). An example of reporting selected occupational conditions, such as carpal tunnel syndrome, is the Sentinel Event Notification System for Occupational Risk (SENSOR) project developed by NIOSH and implemented in many states (26). This project relies on local health care providers to identify and report selected conditions to their state health departments. Action based on surveillance results is part of the system and allows rapid intervention at a local level. At present, SENSOR involves only ten states, and carpal tunnel syndrome is the only nonfatal injury condition currently reported, although some states are planning to target fatal and nonfatal agricultural injuries for reporting under NIOSH funding. Fatal occupational injuries are reported in the Fatal Accident Circumstances and Epidemiology (FACE) project developed by NIOSH. The FACE project relies on detailed and standardized investigation of selected electrocutions, deaths related to confined spaces, and fatal falls to identify opportunities for intervention and prevention.

While there are limited surveillance systems for identifying both occupational mortality (3,4,9,27-29) and morbidity (4,13,30-33), there is no standardized comprehensive system for accurately identifying working populations and the workers within these populations injured or killed. Although existing surveillance systems are not perfect, they may be useful to identify patterns of injury occurrence while new and improved systems are designed and established. Overlap between surveillance needs and data collected for other purposes has resulted in the shared use of some established systems. For example, some workers' compensation programs use a first-report-of-injury form that is designed for employer's reports to OSHA.

In addition to the lack of standardized, comprehensive national data, few companies use occupational injury surveillance systems (except for workers' compensation claims and the OSHA log of injuries) that permit them to identify the causes that most often result in serious injury to their workers. One of the significant needs of those who conduct occupational injury surveillance and etiologic research is standardized coding systems. This is true both at the company level, where the nurse may have different surveillance results than the safety officer, and at the national level, where NIOSH may have different surveillance results than the BLS. Company-based recordkeeping required by OSHA and data that are collected by BLS use the American National Standard Institute (ANSI) Z16.2 coding system. However, medical personnel within companies and the National Center for Health Statistics (NCHS) use the International Classification of Disease (ICD) coding system. Both systems are useful, and the ability to link or use both coding systems in a single data set would increase the usefulness of these data.

Another important need is the inclusion of a brief description of the circumstances of injury. This can best be accomplished with a paragraph summarizing the event that can later be printed out for cases of interest or searched for retrieval of cases including one or more of the key words.

Ultimately, a surveillance system should allow users to promptly identify specific work-places, hazards, employers, or groups of workers with excessive numbers of injuries. The purpose of this identification should be efficient, targeted prevention efforts. To accomplish this may require obtaining data on injuries that are specific to workplaces or employers.

Research Issues

As previously stated, no comprehensive data system currently exists to identify accurately the magnitude and specific nature of the occupational injury morbidity and mortality problem; information on risk factors and details of the circumstances of nonfatal injuries are particularly deficient. Several methods have been used to ascertain the magnitude of the occupational injury problem. These include surveillance efforts mentioned in the previous section and descriptive studies that have examined occupational injury mortality (34-37) and morbidity (19,30,38-43) among various populations and subgroups. The vast majority of efforts identified in the literature on occupational injury have consisted of case reports (44-46) or surveys, frequently without relevant population-at-risk data. Although limited, these efforts provide a basis for subsequent studies on the causes of occupational injury. Such efforts may be particularly important for documenting unusual occurrences and identifying new injury problems, a process that, in turn, facilitates the appropriate design and conduct of analytic studies of specific risk factors and ultimately the development and implementation of prevention strategies.

The difficulties in describing the magnitude and epidemiology of work-related injuries are related directly to the problems of definition, case ascertainment, information retrieval, and communication of results. Standardization of information would ensure that information is available without regard to fault, administrative judgment, or other factors that could change the classification of cases. One of the best surveillance systems is the Fatal Accident Reporting System (FARS) maintained by the U.S. Department of Transportation. This system provides standardized, accurate, detailed information on all deaths due to motor vehicle crashes. Although it is not a good system for identifying occupational injury cases (because that particular data element is dependent upon what the death certificate reports), aspects of FARS could be used as models for systems addressing occupational injuries (47).

In many states, workers' compensation records provide the only source of detailed data on occupational injuries. These records are a source of information regarding the severity and frequency of injuries in specific industries and working environments and may be useful at a local level. However, because of wide variations among states regarding what constitutes a compensable claim and which workers are excluded from coverage, these data are less useful at a national level. The Bureau of Labor Statistics has attempted to standardize the states' information through its Supplemental Data System (SDS) and Work Injury Reports (WIR) programs, which use uniform coding systems and investigative techniques. These programs may be eliminated soon; however, the BLS is developing improved programs to take their place, which will use uniform case definitions and coding in a redesigned system.

There is a lack of comprehensive population-based studies of occupational injury, including morbidity studies, among a variety of industries to determine the extent of the problem more accurately. Available occupational injury data generally do not include sufficient information on agents and sources of injury, worker characteristics, or incident circumstances to generate specific hypotheses for subsequent risk factor research.

In 1983 NIOSH compiled a list of the 10 leading occupational injuries and illnesses in the United States. These 10 injury and illness categories were considered "leading" problems because they occur frequently, are often severe (i.e., fatal or disabling), and are, for the most part, preventable or amenable to prevention. During a national symposium in 1985, multidisciplinary committees developed prevention strategies for the first 5 of these top 10 problems. Among the problems identified were severe occupational traumatic injuries. This category includes a wide range of injuries (amputations, severe lacerations, burns, etc.) and numerous external causes (e.g., falls, motor vehicles, electricity). Although preventing all injuries in the workplace is clearly a long-term goal, progress toward that goal can begin by focusing attention on the most serious problems. Therefore, research priorities should focus on (a) injuries that often result in death or severe disability, (b) injuries that occur in high-risk occupations or industries, and (c) easily preventable injuries that occur frequently, even if they are less severe.

Because more traumatic occupational deaths identified in NTOF data from 1980 to 1985 are attributed to motor vehicle crashes, machinery, homicides, falls, and electricity than to any other causes, such deaths are priority targets. Although the proportion varies depending upon the source of data, motor vehicle crashes probably cause over one-third of all occupational deaths per year (4). Many deaths related to motor vehicles are not coded as the result of work-related injuries and thus are not included in NTOF data. The authors of one study also noted that motor vehicles are a primary cause of nonfatal injury for those workers who must drive or who are exposed to motor vehicles as a part of their job (48).

Machine-related occupational injuries are usually caused by powered hand tools, fixed machinery, and work vehicles such as forklifts and tractors. According to NTOF data for 1980-1985, 13% of all occupational deaths (nearly 850 deaths per year) are related to machines. Sources of nonfatal injury data, specifically the BLS Supplementary Data Systems and the National Electronic Injury Surveillance System, suggest that almost 6% and 12% of occupational nonfatal injuries, respectively, involve machines. The most hazardous machinery includes tractors and other agricultural machines, which were involved in over 600 deaths in 1988; lifting machines such as cranes and forklifts, which were involved in over 180 deaths that year (8); and machines that are often associated with amputations.

Occupational assault and homicide involve a variety of weapons, but firearms cause the great majority of fatalities (34). Although little information is available on the number of nonfatal intentional injuries occurring at work (15), homicide accounts for about 13% of all fatalities in the workplace (7) and is the first or second leading category of fatal occupational injury in 5 of the 10 major industry groups (Table 1). Among women who die in the workplace, 42% are victims of homicide (49). These high homicide rates point to the need for more research and for implementing prevention strategies.

Falling from elevations is a frequent cause of injury and death for workers in many different occupations and industries. During 1980-1985, over 2,700 workers, primarily in the construction industry, were killed in falls from elevations (NTOF data). Because people who are injured in falls often suffer permanent neurological damage such as paralysis or lower back injury, preventing even nonfatal falls deserves a high priority.

Electrical injuries result when a worker is exposed to an electrical current. Injury can be caused by electrical burn or electrocution. Approximately 500 occupational electrocutions occur each year according to NTOF data from 1980 through 1985. Electrical energy is present in virtually all workplaces, although certain occupational groups are at higher risk because of greater exposure through specific job tasks (e.g., line mechanics). Approximately 165 workers are electrocuted each year in construction-related occupations. Agriculture occupations also have at least 50 reported deaths per year due to electrocution and another 80 occur in the transportation industry. Many electrocutions occur when booms, ladders, pipes, or other metallic objects come in contact with powerlines. Unpublished BLS data indicate that about 2,200 electricity-related injuries occur per year in the population of workers covered by their estimates, suggesting a total of approximately 4,000 injuries for the

entire U.S. workforce. Permanent disfigurement, disability, and potential psychological trauma accompanying a severe electrical burn make electricity an important cause of even nonfatal injury.

Acute back injuries account for a substantial proportion of workers' compensation claims and should be targeted. Work-related eye injuries, which occur frequently and are often severe enough to cause loss of vision, are easily prevented and ought to be targeted. Other leading causes of occupational injury that should receive priority attention include blunt force trauma due to being struck by objects, aviation-related injury, injury from explosions, suffocation from mechanical compression (e.g., trench cave-ins), and asphyxiation (in confined spaces) and drowning.

Another research area that warrants expansion is the evaluation of prevention strategies. It is not enough simply to design and implement prevention strategies; it is necessary to evaluate these strategies to ensure they are having the intended effect. Although a strategy may be carefully designed to prevent injuries, unrecognized factors often diminish or eliminate a strategy's effectiveness once implemented. In addition, all strategies should be evaluated to ensure that their use does not result in increased risk for another injury. The results of such evaluations can help in the redesign or modification of injury prevention strategies.

Prevention Issues

Although much remains to be learned through research about effective countermeasures, there are already a number of known prevention strategies that can be implemented now.

One approach to preventing injury is to address the three phases of injury (pre-event, event, postevent) to target the timing of the intervention or to develop prevention strategies. When coupled with the traditional epidemiologic model of agent, host, environment, and vehicle/vector, this provides a matrix framework upon which to develop countermeasures. A combination of measures from all three phases should be used, with preference given to the most effective measure.

Automatic (passive) protection and engineering controls are generally more effective than active protection, which requires workers to participate in their own injury prevention (50). Seat belts are an example of active protection because, although installation of seat belts is required by regulation, the driver must physically attach the manual seat belt or correctly position the automatic seat belt. This requires a conscious effort, putting the burden of protection on the driver. Air bags, on the other hand, provide automatic protection to vehicle occupants because they do not require the occupant's participation. Requiring that all vehicles used for work purposes (fleet vehicles) be equipped with air bags would

automatically provide a measure of protection to the vehicle occupants. For maximum protection, people should use seat belts even in a car with air bags; it has been shown that the presence of air bags does not result in decreased use of seat belts (51).

Despite the great difficulty of changing individual behavior, there has been much emphasis on workers' behavior as the cause of injury and a corresponding tendency to blame the worker, often incorrectly. Automatic (passive) protection is too seldom used in the more hazardous industries such as agriculture and construction, despite the fact that it is more effective than "active" measures requiring effort on the part of each individual worker. In addition to air bags, examples of passive protection include machine guards and new types of syringes and other needle protective devices that prevent needlestick injury among hospital workers. Engineering controls are available for many known hazards but have not been systematically applied and evaluated.

The difficulties in designing interventions relate to the necessity for collaborative research and interactions among scientists from many different disciplines. After risk factors are identified through epidemiologic research, the development of interventions requires a multidisciplinary approach involving engineering, biomechanics, and the behavioral sciences. Laboratory research for developing injury interventions has not kept pace with laboratory capabilities supporting health-related problems in the workplace. For example, computer simulation could be used to establish a basis for improved performance for engineering controls in different workplace environments. Also, occupational hazards that are often not detectable by workers could be detected by using sensors that could be developed in the laboratory. There remains a need for laboratories that focus on developing passive worker protection systems.

Several studies have evaluated employee perception of job hazards or injury risk. In one study, the authors noted that the perceived risk of injury was high for the use of vehicles, machinery, tools, and for falls (52). In another study, researchers used data from several different sources, including the Quality of Employment Survey (1977), the National Longitudinal Survey of Young Men (1978), and the National Longitudinal Survey of Young Women (1980). When compared with BLS injury and illness data, the data from these studies showed a significant association between general worker dissatisfaction with work and reporting of hazards by women (53). This author also noted higher rates of dissatisfaction among workers in more hazardous industries and suggested that workers are generally aware of occupational hazards. Such employees may have valuable insight and should be included in developing prevention strategies.

Lack of employer compliance with Occupational Safety and Health Administration (OSHA) standards is a barrier to effective injury prevention. In a study by NIOSH, based on the National Occupational Exposure Survey, researchers found that only 72% of companies included in the survey complied with OSHA record-keeping requirements (54). Surprisingly, companies that were established prior to 1970 (OSH Act implementation) more often maintained OSHA logs. Additionally, data collected under the NIOSH Fatal

Accident Circumstances and Epidemiology (FACE) project indicated that, of the deaths investigated, most might have been prevented if existing OSHA standards or known safe work practices had been implemented (unpublished FACE data, 1990). This problem is compounded by the fact that most existing OSHA standards and accepted safe work practices have not been systematically evaluated for effectiveness and many causes of workplace injury are not addressed by OSHA regulation (e.g., homicide, which is surpassed only by motor vehicles and machinery as a cause of work-related death). Furthermore, many workers in small companies or who are self-employed are at especially high risk of injury (e.g., farmers and commercial fishermen) but are not under OSHA jurisdiction and may not know that OSHA consultation is available to them.

Government Regulation

In the context of occupational injuries there is a unique opportunity to enforce prevention strategies by legally requiring that employers comply with safety standards set by OSHA or other government agencies.

Government regulation by both federal and state agencies is a necessary but not sufficient part of an effort to prevent occupational injuries. OSHA, as the principal federal regulatory agency with this mission, has two principal functions: promulgating standards and enforcing them with inspections and penalties for noncompliance. Safety standards require employers to take certain steps, such as guarding machines, erecting barricades, maintaining walking and working surfaces, and providing adequate exits and fire suppression equipment. Under OSHA regulations, employers also have a "general duty" to provide for a safe workplace, regardless of whether a specific standard exists. Employers are also legally required to conduct certain medical examinations, inform workers about chemical hazards, make and maintain records, and report fatalities and serious injuries. OSHA inspectors have the authority to enter and inspect workplaces and may issue civil penalty citations if violations of standards are found, but workplaces with 10 or fewer employees are exempt from general schedule inspections. Under OSHA regulations, employers may also be prosecuted for criminal charges. Disputes are adjudicated in federal courts. Some nonfederal jurisdictions also prosecute employers on criminal charges based on serious injuries to workers (55).

Although the OSH Act requires employers and employees to comply with OSHA standards and provides for enforcement of such standards by OSHA, the U.S. Congress intended that the goals of the law would be achieved by all parties working cooperatively towards reducing occupational injuries. The law was to build upon the advances made through employer and employee initiatives and to stimulate employers and employees to institute new and more effective programs. The OSHA Voluntary Protection Program (VPP) has reported success in reducing injuries, although some of the success may be due to self selection of participating companies. In 1988, 94% of the sites participating in VPP had injury incidence rates below their 1987 BLS industry classification rates. Many also showed a decrease in rates of injuries resulting in lost workdays and an increase in injuries avoided.

With limited resources, OSHA's enforcement program is largely reactive. The majority of OSHA inspections are driven by fatalities, catastrophes (where five or more employees are injured), or complaints. With any additional resources, OSHA attempts to target more hazardous industries. Inspections are conducted with no advance notice, and sanctions are imposed after a first-instance violation to provide incentives to employers to remain in compliance with OSHA standards.

The general structure and function of the Mine Safety and Health Administration (MSHA), which has jurisdiction over the mining industry, is the same as OSHA's although there are some important differences. For instance, all underground mines, with no exceptions, must be inspected four times each year, and all surface mines must be inspected twice each year. Furthermore, MSHA inspectors must issue citations if violations are found and may close down all or part of a mine if an imminent danger is found. Under OSHA, issuing citations is not mandatory, and workplaces can be closed only with a court order.

Other regulatory agencies with authority that results in preventing injuries include the National Highway Transportation Safety Administration (NHTSA), the Federal Aviation Agency (FAA), the Federal Railroad Administration (FRA), and the U.S. Coast Guard (USCG), all in the U.S. Department of Transportation. These agencies regulate transportation on highways, airways, railways, and waterways, respectively, which are workplaces for many people. Their regulatory functions include specifications for vehicle and aircraft safety and licensing pilots and captains. Their emphasis is typically on the safety of the travelling public rather than on the prevention of injury to workers, such as truck drivers. As a result, strategies to protect workers have sometimes been neglected.

Other agencies concerned with injury prevention include the Nuclear Regulatory Commission, which regulates nuclear power plants; the Environmental Protection Agency, which regulates the use of pesticides and the use and disposal of other toxic substances; and the Department of Energy, which is responsible for safety and health in its nuclear weapons facilities.

Regulation is more likely to be effective if vigorously and conscientiously enforced. For example, regulation initiated with the passage of the Federal Coal Mine Health and Safety Act of 1969 was followed by a significant reduction in the rate of fatal mine injuries (56). When adjusted for the effects of rate changes in workers compensation, injury rates at specific workplaces showed a decrease for a year following OSHA inspections (57). An analysis of workplace fatalities in California showed that a limited but not insignificant number of deaths could have been prevented with stronger enforcement (58).

Where We Want To Be

To be most effective, efforts to control occupational injury must be well integrated with other injury control efforts at the federal, state, and local levels, including efforts of both public and private entities. To do this, common frameworks for understanding injury occurrence and prevention must be applied. Furthermore, the special concerns associated with occupational injury surveillance, research, and prevention need to be incorporated into all other elements of a national program. This includes (a) identifying occupationally related variables in injury surveillance efforts throughout the spectrum of fatal and nonfatal injury; (b) designing, evaluating, and redesigning high-quality prevention programs that address workers' on- and off-the-job safety; (c) providing acute care and rehabilitation services appropriate to specific occupational groups and injury problems; and (d) educating the public, decision-makers, management and labor, and key professional groups about occupational injury.

With the changing nature of work, the nature of risks changes also. A predominant characteristic of U.S. employment growth in the last several decades has been the rapid growth in the service-producing sector and the decline in the goods-producing industries. Projections for the years 1988-2000 show this trend continuing (59). Major occupational groups projected to grow faster than the overall 15.3% for total employment (1988-2000) include technical and related support occupations; professional specialty occupations; executive, administrative, and managerial occupations; service occupations; and marketing and sales occupations (60). Especially noteworthy is the projected 4.8% decline in agricultural occupations and only 1.5% increase among operators, fabricators, and laborers. Another trend is that nearly two women for every man will continue to enter the U.S. labor force and that by the year 2000, women will comprise 47% of the U.S. work force instead of the current 45%. Other groups whose representation in the labor force will increase are older workers, immigrants, non-English-speaking workers, and other minorities. One impact of these trends is that the effects of injury prevention programs will be difficult to evaluate.

Dimension of the Problem

Year 2000 Occupational Safety and Health Objectives

The Occupational Safety and Health Act of 1970 was intended to provide workers with a safe and healthful work environment. To determine if we are achieving this goal, it is necessary to monitor whether the numbers and rates of injuries and deaths are changing over time compared with a baseline of known occurrence and to evaluate whether prevention strategies are effective. It is also necessary, because of limited resources, to set

long-term goals that include priorities for preventing occupational injuries. Such goals are contained in the Year 2000 Health Objectives for occupational safety and health, which were developed by the Department of Health and Human Services (61).

Unfortunately, many Year 2000 Objectives are predicated on baseline data that reflect limited identification and ascertainment of the injuries of interest. In addition, the Year 2000 Objectives are oriented towards only those injuries currently monitored by OSHA or BLS and thus exclude injuries to some high-risk occupational groups (such as the self-employed). Because improvements in surveillance systems will affect (increase) the reported numbers and rates of injuries, evaluating the true change in injury occurrence will be difficult. Thus any evaluation of success in meeting the Year 2000 Objectives should take into consideration this more comprehensive reporting of injuries.

In addition to these objectives, it is important to examine sex-, age-, and race-specific occupational injury rates, as many demographic variables do affect the risk of injury or influence the injury outcome. For example, the Year 2000 Objectives may be attained because fatal injuries decrease among white males, while other risk groups with different exposures or risk factors may not be affected at all. This lack of homogeneity of effect may affect whether these objectives are truly achieved for all worker groups by the year 2000. Table 4 lists selected Year 2000 Objectives relating to occupational safety and health.

Ideally, all occupational injury should be considered unacceptable, especially severe traumatic occupational injury resulting in death: objectives that call for reductions should be considered minimal goals (Objectives 1 and 2 in Table 4).

Table 4
Selected Occupational Safety and Health Objectives from *Healthy People 2000*

1.	Reduce annual deaths from work-related injuries to no more than 4 per 100,000 full-time workers. (Baseline: 6 per 100,000 during 1983-87)
2.	Reduce annual work-related injuries resulting in medical treatment, lost time from work, or restricted work activity to no more than 6 cases per 100 full-time workers. (Baseline: 7.7 per 100 in 1987)
3.	Implement occupational safety and health plans in 50 states for the identification, management, and prevention of leading work-related diseases and injuries within the state. (Baseline: 10 states in 1989)
4.	Increase to at least 70% the proportion of worksites with 50 or more employees that have implemented programs on worker health and safety.
5.	Establish in 50 states either public health or labor department programs that provide consultation and assistance to small businesses attempting to implement safety and health programs for their employees.
6.	Increase to 75% the proportion of primary care providers who routinely elicit information about occupational health exposures as a part of the patient history and who provide relevant counseling.

Four industries (agriculture, forestry, and fishing; mining; construction; and transportation, communication, and public utilities) account for less than 20% of the workforce but contribute a disproportionate share of deaths — over 50% of occupational deaths, representing average annual rates of 20-28 per 100,000 workers (NTOF, 1980-86).

It is important to distinguish between nonfatal and fatal injuries for the purposes of prevention strategies and goals; Objective 2 in Table 4 addresses this issue. Although the goal of primary prevention is to decrease injury occurrence regardless of outcome, etiologic studies may be needed to evaluate nonfatal and fatal injury separately because of different external causes and risk factors. For example, in the meatpacking industry, a prevention program that is designed to reduce nonfatal injuries related to materials handling and the use of knives may not decrease the number of deaths to these workers (62).

Top priority should be given to requiring that all states implement occupational safety and health programs that go beyond current state or federal OSHA plans (Objective 3 in Table 4). Such plans should be specific for each state, focusing on each state's most prevalent occupational injury and illness problems. The plans should include surveillance activity with identification and follow-up of high-priority industries and workers.

Objective 4 in Table 3 calls for the proportion of worksites (with at least 50 employees) having worker safety and health programs to be increased to 70%. Aspects of these programs should include written safety and health policies, specific safe work procedures for hazardous tasks, personal protection requirements, provisions for training, and such activities as hazard identification and communication programs. Joint labor-management safety and health committees may provide mechanisms for development and implementation of such programs in some companies.

Objective 5 in Table 4 relates directly to businesses or employers with few employees: all states (either through the state health department or the state labor department) are to establish consultation and assistance programs to aid small businesses in supporting occupational safety and health programs for their employees. This is especially important because businesses with 10 or fewer employees are excluded from OSHA scheduled inspections even though they account for 74% of all U.S. businesses, according to the National Occupational Exposure Survey: Analysis Management Interview (63). The authors of one study noted that since OSHA was established, the involvement of many state health departments in occupational safety and health has decreased (64). These authors also cited a NIOSH survey that called for involving local agencies in technical assistance, training, and research activities, including surveillance and epidemiologic studies.

BLS estimates have consistently shown that large firms with more than 500 employees have lower injury rates than do small firms. A 10-year (1977-1986) analysis of OSHA investigations by establishment size shows that establishments with fewer than 20 employees have the highest average injury rate (10 per 100,000) compared with less than 5 per 100,000 for

establishments with 20-99 employees, and 3 or less per 100,000 for establishments with 100 or more employees (65). Similar high rates of 10 per 100,000 were seen during a 6-year period in Colorado for firms with fewer than 500 employees compared with rates of less than 2 per 100,000 for larger firms (27). Employees of establishments with fewer than 20 employees accounted for 44% of the deaths in the OSHA investigation study and 37% of the deaths in the Colorado study. A Japan-based study, which showed an occupational fatality rate comparable with that of the United States, also noted a higher risk for small companies. This was attributed partially to the fact that larger companies may contract out more hazardous job tasks to smaller companies (66). This points to the need to develop interventions for small firms, with the greatest challenge being employers with a workforce of fewer than 11 and those who are self-employed.

Objective 6 in Table 4 is to increase to at least 75% the proportion of primary care providers who ask specific questions about occupational safety and health problems during medical history questions and physical examinations. In addition to their more traditional occupational health role of treatment and counseling, physicians and occupational health nurses should also become more actively engaged in injury prevention at all levels, including identifying unusual or new workplace hazards that result in injuries, educating not only the injured worker but also management regarding hazards, and advocating for the implementation of effective prevention strategies (67).

A comprehensive strategy to attain these six objectives must address the marked differences between rural and urban deaths due to occupational injury. NTOF rates tend to be considerably higher in rural than in urban states. For example, from 1980 to 1985, the highest rates (per 100,000 workers) were in rural states — Alaska (34.2), Wyoming (32.5), Montana (22.6), and Idaho (18.2) while the lowest rates were in heavily populated states — Connecticut (1.6), Massachusetts (2.4), New York (2.7), Rhode Island (3.1), and New Jersey (3.7). Although few studies have examined rural and urban differences within a state, one finding from the Colorado surveillance study was that the rate of fatal occupational injuries in the 53 rural counties was 5.4 times higher than that in the 6-county Denver area (20.2 versus 3.8 per 100,000 workers). Whereas only 17% of the statewide workforce is in the 53 rural counties, 47% of the incidents leading to occupational injury deaths occurred there (27).

Through its rulemaking authority, OSHA is encouraging employers to institute safety and health programs. Beginning with OSHA's Hazard Communication Standard (1987), all employers were required to establish and operate a program to keep employees aware of the hazards of chemicals in their workplace. A natural extension of the Hazard Communication Standard would be a requirement that employers provide workers with information regarding major injury hazards and with methods for controlling the hazards and thereby reducing worker risk of workplace injury. The Hazard Communication Standard was followed by the Hazardous Waste Operations and Emergency Response Standard, which is the first OSHA standard that requires certain employers to develop and implement a complete safety and health program. Other examples include OSHA's Emergency Planning

and Fire Protection Standard, OSHA's Lockout Standard, and OSHA's "Red Meat Guidelines." In addition, in the late 1980s, OSHA issued its program management guidelines for assisting employers in setting up Occupational Safety and Health Programs. OSHA has continued this trend with proposed rulemaking for Process Safety Management for Highly Hazardous Chemicals (1990), which proposes that employers perform self-audits (inspections) to ensure that their own safety program is being properly followed. These programs require employers to monitor the effectiveness of their own programs and their status of compliance with OSHA standards. Employers who achieve a high level of compliance may see reduced injuries in the workplace, although the effectiveness of many safety standards and the overall effectiveness of the OSHA program have not been systematically studied and demonstrated.

Commitment to the Goal: Education To Help Prevent Occupational Injury

Everyone in our society must be committed to the goal of occupational injury prevention. In the following sections, tasks and responsibilities of various organizations and groups are outlined. However, there is one overriding activity that must be accomplished: that is, to make the American public — and particularly top management of U.S. businesses — aware of the effect of occupational injury on our society and convince everyone that this is unacceptable.

One of the ways this can be accomplished is for the federal government to support a national, grass-roots initiative designed to broaden the public's appreciation of the need for occupational injury control and the understanding of injury control strategies. Such an effort can and should be patterned after existing federal programs for grass-roots groups (68).

We should also educate our children, our country's future workforce. This should begin in the early grades, continue in secondary schools, and be an inherent part of business, engineering, agriculture, medicine and allied health fields, and related areas of undergraduate and graduate programs of colleges and universities.

Researchers and practitioners must be trained in the disciplines that can positively impact injury control, particularly epidemiology and safety engineering. To influence safety practices change in a specific industry, injury prevention researchers and practitioners must also be conversant with the engineering and process control concepts and terminology pertinent to that industry. Modern occupational injury professionals must have the training and skills to develop injury surveillance systems, identify high-risk occupations and activities, recognize and reduce hazards, develop and evaluate prevention programs, and help shape and communicate policies and strategies to reduce the probability of injury.

Above all, information about injury risk and prevention must be provided to the worker. Worker right-to-know legislation should be enhanced so that it mandates giving basic information about potential job hazards to all workers, sets up mechanisms for reporting, and facilitates mitigation of specific hazards. Communicating the risks of occupational injury to special groups of workers, such as those who do not speak English, must go beyond translating existing English brochures into other languages. Aggressive outreach programs are necessary to ensure that this information reaches these workers. Populations outside the mainstream of the American worker require unconventional methods, which may include the use of ethnic language newspapers and radio and television broadcasts. Points of contact may also include hiring halls and street corners where employers recruit daily laborers.

Surveillance Issues

A comprehensive, national occupational injury reporting system should be developed to improve the timeliness, accuracy, and completeness of occupational injury surveillance at all levels — from the plant, facility, and company level to the level at which national trends are monitored and research priorities are established. By law, all occupational fatalities must be reported to OSHA. Ideally, all fatalities would be reported by employers and investigated by federal OSHA or state agencies according to standard fatality investigation protocols. All injuries would be recorded and submitted to the appropriate monitoring agencies. Ideally, all injuries would be reported by employees and recorded and investigated by employers, and techniques for hazard and exposure surveillance would be in place to guide prevention and research activities. Other fatality and injury reporting systems should be adjusted to enable injury prevention specialists to identify work-related injuries. For example, death certificates should include accurate "injury at work," occupation, and industry information, both on the hard copy and in all computerized vital statistics files.

The Occupational Safety and Health Act of 1970 requires the Secretary of Labor, in consultation with the Secretary of Health and Human Services, to develop and maintain an effective program to collect, compile, and analyze statistics on occupational injuries and illnesses. To improve inadequacies of the current system (10), the Bureau of Labor Statistics (in cooperation with many state governments) is developing a three-part survey program that (a) counts the number and frequency of work-related injuries and illnesses nationwide, (b) develops profiles of worker and case characteristics for lost worktime incidents in selected states, and (c) focuses on the circumstances surrounding those work-related injuries and develops injury prevention techniques from the perspective of the injured worker. This proposed nationwide survey would be based on a uniform set of definitions for recordable injury and illness cases and their characteristics.

Since 1971, the Bureau of Labor Statistics has developed fatality estimates as part of its annual sample survey of occupational injuries and illnesses. However, these estimates have undercounted many occupational fatalities (3,10,34). The Bureau is currently designing a

Census of Fatal Occupational Injuries that will be used to coordinate and integrate information from death certificates, workers' compensation reports, and other administrative records. Besides private wage and salaried workers, the fatality count will include the self-employed, farmers on small farms, and workers in the public sector. In addition to providing more accurate counts of fatalities, this approach will permit more detailed analysis of the circumstances surrounding the incident and of the victim's characteristics than did past BLS surveillance data.

The NIOSH Division of Safety Research conducts surveillance of fatal occupational injuries (through the NTOF project) and field investigations of selected occupational fatalities (through the FACE project) to obtain case-specific information for research and prevention efforts. NIOSH is developing a program that will expand and integrate these projects to collect more timely and detailed data to support more quantitative research. In conjunction with the current objective of assisting states to develop the capacity to conduct occupational health and safety research, NIOSH plans to initiate a state-based fatal occupational injury identification and investigation network. Integrating surveillance and investigative data at a state level, with timely information transfer on a national basis, will increase the validity and completeness of these data at the national level and will also enable states to develop projects and policies tailored to their specific needs. Such national surveillance systems should first be established for the most severe injuries; the first step would be to improve fatality reporting and the second to develop a method to record all hospital discharge data. In addition, in company-level data, injuries should be categorized as those causing death, those causing hospitalization, and those causing lost worktime.

Conventional surveillance methods may fail to identify certain segments of the population at especially high risk for occupational injury, such as workers in some small businesses, or workers in the underground economy such as "sweatshops" and other places of employment that exploit undocumented workers. Methods must be developed for preventing injuries among these workers without exposing them to employer or immigration service retaliation.

Research Issues

Research should be planned and conducted by researchers and organizations representing multiple approaches and disciplines but sharing common priorities, objectives, and communication channels.

Epidemiologists and statisticians in government, universities, and other public and private organizations, should coordinate their data collection and analysis efforts to (a) improve and standardize occupational injury surveillance systems, (b) systematically and comprehensively describe the occupational injury experience in the United States, and (c) develop and test hypotheses aimed at identifying injury risk factors via the study of specific injury problems in specific populations. Public and private sector administrators, policymakers,

management, and labor should join forces at the national level to set priorities for research and prevention efforts.

Engineers, ergonomists, safety professionals, industrial hygienists, and experts in biomechanics and the behavioral sciences should address the most compelling problem areas by studying the components of workplace systems (including people), and the processes, tasks, and tools involved to identify potential causal mechanisms, opportunities for intervention, and potentially applicable prevention strategies.

Teams of engineers and other technical specialists should use emerging modeling and computer simulation technologies to study the processes, forces, and factors operating in the workplace and to move the consideration of system safety more and more into the conceptual and design phases of system development. Research and development efforts should emphasize "passive" rather than "active" measures of prevention, such as the design of workstation and worker protective systems incorporating intelligent microenvironments that feature sensors, microprocessors, adaptive protective mechanisms, and display and imaging technology to protect workers and warn them of hazardous conditions or their onset.

Evaluative research should be increased dramatically as the wide array of potential preventive strategies, including existing or planned safety regulations and information dissemination/risk communication efforts, need to be tested for relative effectiveness under variable conditions and workplace characteristics.

The close collaboration of specialists, particularly those of the engineering-oriented disciplines with epidemiologists and statisticians, will be critical to the design of research that leads to the identification, implementation, communication, and evaluation of injury prevention strategies. Epidemiology offers a perspective on the phenomena associated with injury that augments the engineering perspective, and vice versa.

Prevention Issues

Initial prevention efforts should include implementing and evaluating available injury control technologies and strategies. Applicable standards and other guidance should be closely followed and compliance stringently enforced. Programs emphasizing the transfer and sharing of effective preventive technology, among companies and countries alike, should be developed or expanded, with a particular emphasis on making cost-effective injury prevention technology available to businesses that could not otherwise afford it.

The mandates of OSHA and NIOSH should be expanded to include all workers, including the self-employed, those employed by small companies, and those with jobs in transportation

and the public sector. Even though other agencies have jurisdiction over some aspects of safety, OSHA should still address all situations involving worker safety. For example, even though the Department of Transportation has jurisdiction over the safety of the travelling public, OSHA should address issues concerning the safety of workers who travel as part of their jobs.

Model safety programs should be widely available for adoption and adaptation by specific employers, with public and private sector worker safety organizations tending more toward consultative and cooperative roles.

The legal and moral rights of workers and unions to act to prevent injuries and to participate in hazard abatement should be expanded (while also providing reasonable protection for employer interests). Workers' rights should include the following:

- Enhanced worker right-to-know legislation that provides basic information about job hazards and the mechanisms for reporting and facilitating mitigation of specific hazards.
- Strengthened protection for workers who refuse to perform hazardous work that may violate safety standards or which exposes them to risk of serious injury or death.
- Enforcement of the right of individual workers to challenge retaliatory discharge for exercising their rights under the OSH Act.
- A mandate for worker participation in worksite inspections by regulatory agencies, including "walkaround pay" for participation in all phases of an inspection (from initial interview through closing conference).
- Expanded worker participation in OSHA proceedings from issuance of a citation through final adjudication.
- Right of access to the worksite for workers, their representatives, and consultants to investigate hazards and injuries.

As corporate leaders, industrial planners, equipment and tool manufacturers, union leaders, employers, and others making decisions that affect workplace safety grow more aware of the benefits of safe, injury-free systems, prevention should evolve from its reliance on education, personal protection, safeguarding, and retrofitting to the design of intrinsically safe systems incorporating integral, nonobtrusive, passive controls.

How We Get There

A Summary of Recommendations

The following recommendations are based on four changes needed to realize the goal of preventing occupational injury. These changes are (a) increased research on the factors associated with high injury risk, which requires increased resources (money and personnel); (b) increased education about occupational injuries aimed at workers, employers, the public, and legislative bodies that set research priorities; (c) increased collaboration and coordination to eliminate gaps, redundancy, and adversarial relationships (whether among governmental agencies or between labor and management); and (d) improved leadership in preventing injuries by promoting compliance with OSHA standards and by implementing preventive strategies that have proved effective.

Federal Organizations

Congress

Congress should appropriate the funds necessary to support occupational injury surveillance and research as it recently did in appropriating money for NIOSH to conduct research in agricultural and construction safety and health. Congress should also increase resources (budget and staff) for government agencies funding or conducting occupational injury research or other prevention-related activities, such as developing and enforcing job safety standards.

Congress should also increase resources that are needed for training occupational injury prevention specialists; these resources should go to academic and research centers such as the NIOSH Educational Resource Centers.

Congress should adequately fund efforts by the Department of Labor (specifically OSHA and BLS) to improve and maintain a surveillance system that uses standardized coding and includes workers' compensation claims from all states in order to support research based upon these data.

In addition to appropriating funds, Congress can play an important role by providing legislative mandates promoting occupational injury prevention and research. Congress should create a legislative mandate to allow OSHA to increase responsibility, authority, and activities for the safety of all U.S. workers, including employees in small businesses, the self-employed, and all workers in transportation, agriculture, and the public sector. In addition, Congress should pass legislation that expands criminal prosecution (not merely

monetary penalties) for employers whose willful disregard for human life and welfare results in fatal or serious injuries to workers. Congress should also mandate the legal right for workers to participate actively in their own injury prevention, including their right of access to the worksite for investigating hazards. Congress should also strengthen the protection for workers who refuse to perform hazardous work.

Federal Agencies

All organizations within the Public Health Service should help parties involved in occupational injury prevention activities, including private sector organizations, to communicate to the public that occupational injury is a serious issue. Many federal government agencies are directly responsible for or are indirectly involved in occupational injury prevention. These agencies need to collaborate to promote occupational injury prevention as a high priority in all federal agency programs.

The federal government (as a large employer) should also set an example with its own programs to reduce injuries to government workers (e.g., purchasing only cars equipped with air bags for government fleets) and to workers employed by contractors paid by federal dollars. All federally sponsored loans and contracts should be denied to employers with a record of noncompliance with OSHA standards or who lack injury prevention programs. Audits should be conducted to determine compliance with OSHA standards as well as countermeasures that are known to be effective. All federal construction contracts should have an injury prevention component built into the contract bidding process in the same manner that financial stability is included. Potential bidders should be required to demonstrate a low rate of injuries, sufficient injury prevention activities, and compliance with safety standards, or they should be eliminated from the bidding process. NIOSH should serve as a model and should help other government agencies develop injury prevention programs.

Government agencies should develop an award program for employers or trade associations that demonstrate effective injury prevention efforts. This program should be highly publicized to provide an incentive for companies to accurately identify, report, and record occupational injuries and then develop prevention programs that provide examples of positive cost-benefit studies for injury prevention.

Documentation of effectiveness of prevention strategies, like the documentation of vaccine efficacy in preventing infectious diseases, should be mandated at the federal level, with augmentation in funding to mount an effective program.

Under NIOSH's leadership, Department of Labor (DOL) and other federal agencies and academic researchers involved in occupational safety and health research should collaborate in designing a model surveillance system for recording injury morbidity and mortality. To conserve scarce resources and to promote consistency of data, those involved should avoid duplication of efforts. Groups that have overlapping data needs should cooperate and coordinate to produce a single data collection instrument that would be the basis for a

central national system. The model surveillance system should cover all needs of different groups. Data elements and coding criteria should be standardized. A set of data elements and coding criteria that would be common to existing occupational injury surveillance systems should be developed and used. National systems such as the NTOF, BLS, and FACE databases, the National Council for Compensation Insurers database, state-based surveillance systems and workers compensation data, and local trauma registries may be used in designing model systems. A surveillance system similar to that of the Mine Safety and Health Administration, which requires reporting of all injuries, hours worked, number of employees at risk, and near-hits or events that could have resulted in a severe injury should be considered.

While this strategy defines a coherent plan for accumulating better surveillance data, there are steps feasible now that can help us move towards improved surveillance. The first step is for NIOSH to expand existing national surveillance systems to include reporting of sentinel, nonfatal injuries (e.g., those requiring hospitalization), especially for high-risk industries such as agriculture or construction. In addition, NIOSH should expand the FACE project in all states to include all causes of traumatic occupational fatalities. The BLS should continue to develop its Census of Fatal Occupational Injuries program and establish its revised Occupational Safety and Health Survey.

The second step is to identify and enumerate workers at risk; NIOSH needs to work with the BLS and the Bureau of Census to improve the enumeration or estimates of all worker populations, especially those currently not included in BLS data systems. Better denominator data or the number of workers in given occupations, are necessary to understand fully the magnitude of the problem.

NIOSH, as the lead federal agency mandated to conduct research on occupational injuries, should expand its program more into research and interventions as opposed to surveillance. NIOSH should also identify and study populations of workers at high risk that have been inadequately addressed (e.g., workers in small businesses, the self-employed, children and adolescents, minority workers, public sector employees, and temporary, migrant, or seasonal workers).

NIOSH needs to expand its dissemination of information to include those who are at risk of injury, the workers. Work hazards and the strategies aimed at preventing injuries associated with these hazards should be communicated to workers as well as employers.

OSHA needs to expand its program of standard development, standard enforcement, inspection, and evaluation. First, OSHA should conduct random inspections of small companies, including those currently excluded from federal OSHA compliance (e.g., small farms with less than 11 employees). OSHA should also target inspection strategies and evaluate which inspection plans work best for different industries.

OSHA should also increase enforcement of the general duty clause for workers to whom no standards apply, such as those whose workplace is a motor vehicle. OSHA programs should be developed for public sector workers in every state, because these workers are not currently regulated by federal OSHA. Such programs should include workers in highway departments, correctional institutions, and state hospitals.

OSHA should enforce increased compliance with its existing standards. In addition, OSHA, in collaboration with NIOSH and MSHA, should develop methods for quantitatively evaluating standards; ineffective standards should be modified and re-evaluated. Standards should also be developed to address hazards not covered by existing standards, such as newly identified hazards. For example, standards could be developed to reduce the risk of intentional injury in situations such as the shooting of taxi drivers and workers at convenience stores. Information dissemination efforts, worker education and training, and specific regulatory processes should also be evaluated at the federal level. If in certain settings, these measures are found to be ineffective, they should be revised. However, if there is reasonable evidence that a strategy is effective, it should be implemented immediately rather than waiting for definitive proof of its effectiveness.

OSHA needs to use injury data (obtained through BLS and NIOSH surveillance and research activities) to set rulemaking priorities that will lead to new and improved standards. OSHA should extend the concept of hazard communication by promulgating a standard that requires employers to provide workers with information regarding major injury hazards and methods for controlling the hazards. Worker right-to-know legislation should be enhanced to ensure that all workers have basic information regarding potential job hazards and mechanisms for reporting and facilitating mitigation of specific hazards.

Vital statistics data provide information on occupational deaths; however, these data could be considerably more useful if modified to be better adapted for use in occupational mortality surveillance. NCHS should provide states with resources and encourage states to routinely complete the injury-at-work box on death certificates and expand efforts to provide training on how to complete this item. All death certificates that indicate injury at work should include the decedent's usual and current occupation and should be industry coded and computerized with coding rules developed by NIOSH, NCHS, and the Bureau of the Census.

Agriculture has been shown to be a high-risk industry, yet OSHA has no jurisdiction to regulate many farms. The U.S. Department of Agriculture (USDA) should collaborate with NIOSH in its outreach effort to improve safety and health in agriculture and rural small businesses (for states with USDA jurisdiction over small business).

State and Local Government

State, county, and local governments need to focus on occupational injury priorities within their boundaries in addition to supporting and responding to the need for standardized, national data. Each state should designate a lead agency to coordinate occupational injury prevention and control activities involving all relevant state agencies that deal with health, labor, workers' compensation, highway safety, emergency medical services, vital statistics, law enforcement, and agriculture. These agencies should cooperate in identifying research needs, using state data to identify risk factors for occupational injury, and developing and evaluating prevention strategies. Occupational injury control activities should be coordinated with all other injury control activities at the state and local level. Although attention to occupational injury historically has been separated from other areas of injury research and control, efforts to prevent occupational injury must be well integrated with other injury prevention efforts at the state and local level (in addition to the federal level) as well as private and public programs. To facilitate this integration, officials must apply common standards for studying and preventing all injuries.

The focus of centers for injury research or prevention should be expanded to include occupational injury. In addition to their other activities, these centers should train professionals in occupational injury prevention, provide continuing education credits in occupational injury prevention, and support research directed towards occupational injury.

State health departments or other state agencies should be actively involved in the onsite investigation of all work-related deaths, especially those not investigated by OSHA, MSHA, or the National Traffic Safety Board. These deaths should be investigated in a similar manner to deaths from communicable diseases. Surveillance data and copies of the investigative reports should be provided to federal agencies such as OSHA and NIOSH. Worker injury prevention programs should be developed at the city, county, or state level for workers who are in the public sector.

Local prosecuting attorneys and law enforcement officials should be encouraged to investigate severe injuries (resulting in death or permanent disability) and to pursue criminal prosecution of employers who willfully violate OSHA standards or show evidence of criminal negligence.

Medical examiners and coroners in states and counties should indicate on their investigation forms whether a death is work-related and should code and computerize this information to facilitate research based upon these data. State vital statistics departments should also code and computerize this information. State agencies should require that injury-at-work information be included on hospital discharge records in addition to external cause-of-injury coding.

State and local permit and licensing requirements (e.g., for construction permits) should include worker safety as the primary consideration in the application process.

Employees and Unions

Employees and unions need to exercise their right to a safe workplace by becoming more active in all aspects of workplace safety. A key to employees' preventing occupational injuries is the right to refuse tasks that expose them to serious hazards or that violate established safety standards. Unions should promote occupational injury prevention through increased involvement in OSHA standard setting and enforcement and through collective bargaining that places the highest priority on safe working conditions for employees. Unions and employers should work together to address effectively the safety and health concerns of all members and employees. Common areas of interest include developing and establishing injury surveillance systems and ensuring that employers implement and evaluate comprehensive injury prevention programs. Another way that workers can actively participate is by identifying and reporting potential hazards in their workplaces. Workers should also actively participate in federal efforts to develop injury prevention priorities and strategy.

Unions should help promote occupational injury prevention for workers who do not work in a defined workplace or within a corporate structure. Nonunion employees should, individually and in groups, fully use their rights to promote safe workplaces. In all work settings, employees share with employers the responsibility for safe work practices. Unions should energetically work to convince their members to comply with company, state, and federal safety rules.

Workers should participate (with full salary) in all phases of worksite inspections by regulatory agencies, from the initial interview through the closing conference. In addition, workers should become actively involved in OSHA proceedings, from the issuance of a citation to the company through the final adjudication. Workers should also exercise their rights under the OSH Act to file their own legal actions, such as challenging retaliatory discipline or discrimination for exercising their safety and health rights.

Employers and Companies

While it has been clearly established that employers have assumed their responsibility to comply with OSHA standards, they should also incorporate other injury prevention strategies into their corporate policy and practice. For instance, companies should establish safety and health committees and begin processes that involve and empower workers to monitor overall work-related safety and health conditions. Committees should include employee representatives as well as representatives from the occupational safety and health team (e.g., physicians, nurses, injury prevention and safety specialists, industrial hygienists, and safety engineers).

Employers, in collaboration with employees and unions, should establish plant- and company-based surveillance and research systems, based on and consistent or comparable with the national systems. These should be used to develop and evaluate injury prevention strategies. Employers, employees, and union members should work together to ensure that

potential hazards are systematically identified and that training programs are built around job hazard analyses. An example of productive collaboration between workers/unions and employer/management is the joint programs of the United Autoworkers and the Ford Motor Company. Using money set aside by collective bargaining agreements, they established a National Joint Committee on Health and Safety that has since conducted several specialized health and safety training programs. A recent program includes training over 100,000 hourly workers and their supervisors to recognize potential hazards at each work station and instructing these workers on the procedures to follow to have the company eliminate such hazards.

All work-related injuries, not only those resulting in lost time, should be identified, reported, and recorded. Employers should support worker- or union-developed studies and research needs. Comprehensive studies on both mortality and morbidity associated with different job tasks within different industries should be emphasized. Hazards should be identified before they result in injury to a worker. This is especially important as a company introduces new technology into the workplace. Before and during this transition, the company must evaluate the impact this new technology will have on worker safety.

Minor injuries and near-hits often precede more severe outcomes and generally indicate inefficient and/or degraded process control. Given an appropriate safety climate, workers and supervisors can play very beneficial roles in detecting hazards and suggesting corrective actions. Employers should encourage workers to identify and report hazards. Employers or labor-management committees (where feasible) should investigate all injuries and near-hit events, and immediately begin to develop procedures that prevent recurrence, rather than waiting until many workers have been injured before beginning data analysis. Prevention strategies should emphasize engineering controls and injury countermeasures that do not place the burden of responsibility upon the worker at risk. Although it is preferable that employers use "state-of-the-art" countermeasures, they often must settle for the most effective ones that their resources will permit.

Companies should incorporate injury surveillance, research, and prevention into the corporate medical, safety engineering, or other appropriate existing organizational structures. Although most companies do not have the resources to have an epidemiologist trained in occupational injury, each company should have someone on its staff who is responsible for the surveillance of injuries and for safety engineering (such as hazard identification and engineering controls). These persons should be dedicated to preventing occupational injuries using the public health approach.

Companies should develop expertise in identifying major hazards and high-risk work activities and in evaluating injury prevention programs (by hiring experts, training their staff, or consulting with academic researchers). As the larger companies with more resources develop this capacity, they should disseminate information on effective prevention strategies to smaller companies. Company representatives should attend industry-wide professional

meetings and share information about effective injury prevention countermeasures and cost- benefit studies.

Companies should develop, implement, and enforce a comprehensive injury prevention program that includes training for employees. This training should include not only the specific skills needed to perform a particular job when the process is operating normally, but also information on what to do when the process malfunctions or needs adjustment or repair. All employees should also receive orientation to general safe work practices and education relevant to their job duties and the environment in which they work. This training should be immediately given to all new employees and to veteran employees on a continuing basis. Programs currently available to help companies develop safety programs include the Network for Employers for Traffic Safety (NETS), which was designed to assist employers establish comprehensive highway safety programs for employees.

Employers should make safety a part of all company activities and procedures from procurement to quality assurance. Workplace design factors must be considered in the bidding specifications for the equipment that will be purchased or constructed for the production process. For example, purchasing agents must not negotiate away specifications related to safety features in exchange for a lower price or faster delivery schedule. For existing operations, process reviews should involve a team approach (engineering, quality, and safety), with input from operators who have actually been running the process. Occupational safety and health should be the "bottom line" component of all company activities.

Companies should emphasize prevention efforts that focus on implementing and evaluating available injury control technologies and strategies. Applicable standards and other guidance should be closely followed and compliance stringently enforced.

Employers should assume an active role in modifying the workplace to help people who receive a permanent disability return to work. Returning to work after incurring a disability is an important part of the injured person's adjustment and reintegration into society. Because there is greater potential to control the work environment (compared to the community), it is possible to place the burden of responsibility for enabling the disabled person to return to work on the employer rather than the disabled worker. Employers should develop and implement rehabilitation programs that comply with requirements outlined in the Americans with Disabilities Act.

As part of the company program to prevent disability associated with workplace injury, the company should provide emergency medical care at the worksite for all those injured at work. This care may range from an occupational health nurse and physician onsite at all times to local emergency medical services that can reach the worksite rapidly enough to provide early intervention after injury.

All publicly owned companies should include a report on occupational safety and health in their annual reports and should have annual safety conferences that are chaired by the company executive officer.

Insurance Companies

Insurance companies can directly benefit from decreased injury in the workplace and can contribute to this decrease in several ways. Insurance companies should provide policy holders with information about the financial benefits of injury prevention programs. Insurance companies that provide workers' compensation to large and small companies could provide the expertise to enable these companies to develop and implement prevention strategies.

Insurance companies should cooperate with other organizations and their clients to encourage sharing of data and prevention strategies and help increase cooperation and collaboration between government agencies and other groups. Officials operating state and federal workers' compensation programs should work with other federal and state officials to standardize, refine, and analyze data collected through injury reports from workers and employers.

Academic and Research Centers

The federal government currently sponsors a number of research and training centers around the country, including the Educational Resource Centers (ERCs) and Centers for Excellence sponsored by CDC's NIOSH and the Injury Control Research Centers sponsored by CDC's National Center for Environmental Health and Injury Control. These centers should offer multidisciplinary and comprehensive training in the prevention and control of occupational injury. Their graduates should have the knowledge and skills to develop and implement effective occupational safety and health programs and the means to evaluate the impact of such programs. These programs should be linked with state and local agencies involved in occupational safety and health; collaborative activities with local and regional industry should be encouraged and supported; and outreach activities should be conducted for current and future labor and business leaders and managers.

Using a multidisciplinary approach, academic and research centers should conduct research on injury occurrence, risk factors, and prevention strategies. Epidemiologists and biostatisticians should lead the way in identifying and describing cases through surveillance and research, identifying risk factors through analytic epidemiology, and evaluating preventive strategies. An important component of occupational injury surveillance and research is the development of a standardized definition of work-related injury. Academic researchers should work with NIOSH and DOL to develop a definition that would cover all the needs of different groups and that would be consistent or at least translate across different data sources and surveillance systems.

Research efforts should focus on injuries that most often result in death or severe disability (e.g., brain and spinal cord injuries, burns, and amputations) because of their impact on the individual, family, and society. Research should also focus on high-risk industries and occupations (agriculture, construction, transportation, mining, laborers, truck drivers, etc.); on high-risk states or regions (e.g., rural areas); and high-frequency injuries, regardless of severity, that can be easily prevented. As surveillance capabilities improve, other problem areas will be identified.

Researchers should examine sex-, age-, and race-specific rates, as well as how other variables affect risk of injury. Special emphasis should be placed on conducting research concerning older, part-time, and self-employed workers; public sector workers; military employees; women; and minorities. Because fewer members of these groups are at risk or because estimating the number at risk is especially difficult, these populations are often excluded from studies. As an adequate baseline of descriptive information becomes available through the surveillance and research activities described, researchers should begin to test etiologic hypotheses and determine the causal pathway of occupational injuries by using more rigorous, quantitative studies.

Laboratory-based researchers should emphasize the development of "passive" rather than "active" prevention strategies. NIOSH researchers, in concert with researchers in academic institutions and industry, should develop the necessary laboratory capabilities for developing and evaluating passive worker protection systems, ergonomics, biomechanics, safety hazard sensors, and the human factors involved in occupational injury. Laboratory researchers should make increased use of technological tools in injury prevention research (e.g., computer simulation to simulate the workplace and predict injury on the basis of changes in the job task or workplace).

In addition to conducting occupational injury research, academic institutions must work toward incorporating principles of injury prevention into curricula for business, architecture, engineering, medical, public health, agriculture, and nursing schools. Improved prevention-oriented curricula must be developed for safety engineers and other professionals. Medical schools should substantially increase training in occupational medicine for students, and occupational injury prevention should be included on board examinations in relevant specialties such as internal medicine and orthopedics. To be accredited, schools of public health should be required to offer coursework devoted to occupational injury control; they should also ensure that all students are exposed to information about injury epidemiology and control within their core, required courses. The nation's business schools, which have neglected important opportunities in injury prevention, should be encouraged to focus on occupational safety and health and to make injury prevention a curriculum priority.

Occupational and injury prevention information should be included in curricula beginning at the elementary and high school levels, particularly in secondary school science, industrial arts, home economics, and vocational-technical programs. Instructors of these courses or components should teach the scientific concepts that form the basis for injury prevention.

They should also emphasize that occupational injuries are preventable and can most effectively be prevented by designing the working environment, equipment, and tasks to minimize hazards. Vocational counselors should receive training in the injury risks faced in various occupations.

Once there is research supporting prevention strategies, these strategies should be implemented and evaluated to determine their effectiveness. Academic and research centers should develop and evaluate injury prevention and control strategies in collaboration with federal and state agencies and representatives of the private sector, including employers, workers, and advocacy groups.

Advocacy Groups

Advocacy groups can play an important role in helping to focus the attention of the public and legislators on the problem of occupational injury. Advocacy groups should help promote state and federal legislation that enhances the protection of workers and ensures that more funding will be provided for training and research (similar to what has occurred with the AIDS movement). Advocacy groups should also develop a national grass roots organization (similar to Mothers Against Drunk Driving) to educate the public on the problem of occupational injuries. In addition, advocacy groups should work with employers in the private sector to establish occupational injury prevention as a top priority.

Media

People who work in the media can educate both workers and the general public by improving reporting of circumstances, economic and social costs, and preventability of occupational injury; by disseminating summaries of studies to major news groups; and by advertising the magnitude of the problem. Journalists and other media personnel could help establish occupational injury as an important public health problem by increasing visibility through promoting public service announcements that portray behaviors and actions which incorporate occupational injury prevention principles. Media personnel could also help by dispelling the current myths on injury causation.

Professional Associations

Professional associations should also help educate the public. These associations (e.g., Association of State and Territorial Health Officers or Council of State and Territorial Epidemiologists) should help state health departments implement surveillance systems and support legislation relating to occupational injury prevention.

The Council of Professional Associations on Federal Statistics should enlist the participation of BLS, NIOSH, OSHA, NCHS, and congressional staff to develop ways of obtaining appropriate data for national surveillance and research of occupational injuries.

Different professional associations need to develop methods for exchanging information (e.g., soliciting papers for professional conferences from members of disciplines related to injury prevention). Professional associations that might be involved in this exchange include the American Public Health Association, the American Society of Safety Engineers, and the American Association of Occupational Health Nurses. Associations of health-care professionals that provide or require continuing education credits to members should include credits in occupational injury prevention.

Private Foundations

Private foundations should give high priority to funding research and education directed towards preventing occupational injuries.

Conclusion

Occupational injury is a public health problem that demands immediate attention. Although there are constraints that have diminished our past and affect our present success in preventing injuries to U.S. workers, there are also data and prevention strategies available now that should be used to protect workers today. We must improve our surveillance and research capabilities, and we must develop, implement, and evaluate successful countermeasures to injury. The recommendations included in this chapter provide a template that can help us move towards the goal of preventing work-related injury in the United States.

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