

Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries

Part 1

- **Occupational Lung Diseases**
 - **Musculoskeletal Injuries**
 - **Occupational Cancers**
- **Severe Occupational Traumatic Injuries**
- **Occupational Cardiovascular Diseases**

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Preface

The Association of Schools of Public Health (ASPH) is pleased to present this publication of proposed strategies for the prevention of occupational lung diseases, musculoskeletal injuries, occupational cancers, severe occupational traumatic injuries, and occupational cardiovascular diseases. The strategies represent an initial step toward bringing work-related diseases and injuries to the forefront of the Nation's agenda for prevention.

Having learned about the National Institute for Occupational Safety and Health (NIOSH) strategies for the prevention of occupational diseases and injuries and because of its leading role in advocating disease prevention and health promotion initiatives at the national level, the ASPH proposed that ASPH and NIOSH co-sponsor a meeting that would address these novel strategies. Consequently, a National Symposium on the Prevention of Leading Work-Related Diseases and Injuries was held in Atlanta, Georgia, on May 1-3, 1985.

This national convocation of the occupational safety and health community represented an opportunity for the best professional opinions to be aired. The Symposium consisted of 51 expert panelists who served as faculty of the five workshops and over 450 participants representing industry, business, trade unions, voluntary organizations, the professions, and academia. The five preliminary prevention strategies were introduced for discussion, revision, elaboration, and further development. The proposed prevention strategies that follow are the results of this professional effort to date.

Interested symposium participants and readers are urged to study and discuss these proposed strategies further and utilize the recommendations as is appropriate to them. Others may want to be involved in the further evaluation of these strategies. Their input for revision of these documents is actively sought.

These are proposed strategies in a continual process of review and revision. These proposed strategies are not to be considered as final statements of policy of ASPH, NIOSH, or of any agency or individual who has been involved. Hopefully, they will be useful in the quest to prevent disease and injury in the workplace.

It is a pleasure to work in this cooperative venture with J. Donald Millar, M.D., Assistant Surgeon General and Director of NIOSH, and his staff. We take pride in presenting these preliminary products of our effort.

Michael K. Gemmell
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Introduction

In 1970, the Congress of the United States enunciated an historically important vision when it passed the Occupational Safety and Health Act. Through this Act, Congress sought "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions. . ."¹ In 1979, the U.S. Surgeon General, in "Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention,"² described the health of the American people and established broad national goals for improvement through prevention.

To help bring this vision a step closer to realization, we in the National Institute for Occupational Safety and Health (NIOSH) developed and published in 1983, a "suggested list of Ten Leading Work-Related Diseases and Injuries" (Table 1.).

Table 1. Suggested List Of Ten Leading Work-Related Diseases and Injuries*

- | | |
|---|---|
| 1. Occupational lung diseases:
asbestosis, byssinosis, silicosis,
coal workers' pneumoconiosis,
lung cancer, occupational asthma | 6. Disorders of reproduction:
infertility, spontaneous abortion,
teratogenesis |
| 2. Musculoskeletal injuries:
disorders of the back, trunk, upper
extremity, neck, lower extremity;
traumatically induced Raynaud's
phenomenon | 7. Neurotoxic disorders:
peripheral neuropathy, toxic
encephalitis, psychoses,
extreme personality changes
(exposure-related) |
| 3. Occupational cancers (other than lung):
leukemia; mesothelioma; cancers of
the bladder, nose, and liver | 8. Noise-induced loss of hearing |
| 4. Severe occupational traumatic injuries:
amputations, fractures, eye loss,
lacerations, and traumatic deaths | 9. Dermatologic conditions:
dermatoses, burns (scaldings),
chemical burns, contusions
(abrasions) |
| 5. Occupational cardiovascular diseases:
hypertension, coronary artery
disease, acute myocardial infarction | 10. Psychologic disorders:
neuroses, personality disorders,
alcoholism, drug dependency |

* The conditions listed under each category are to be viewed as *selected examples*, not comprehensive definitions of the category.

1. Public Law 91-596. 91st Congress S. 2193. December 29, 1970.

2. Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1979; DHEW publication no. (PHS) 79-55071.

Problems were included on the list based on their frequency of occurrence, the severity of the problem in affected individuals, and the amenability of the problem to prevention. Interestingly, this contemporary list includes problems emphasized half a century ago by Dr. Alice Hamilton, the first American physician to devote a full professional career to industrial medicine. Her pioneer studies of the “dangerous trades”³ covered a broad field, and she initiated a professional movement that has been gaining momentum ever since.

Today, prevention is an idea whose time has come to a place of prominence in our national awareness. We continue to face the traditional occupational diseases and injuries, but we must also face new problems that the new technologies will present. Today, we have the scientific knowledge necessary to formulate national strategies for the reduction of several important occupational diseases and injuries. Hence, working groups composed of NIOSH scientists from various disciplines have drafted proposed national strategies for the prevention of each of the first five entries on the NIOSH suggested list:

- Occupational lung diseases
- Musculoskeletal injuries
- Occupational cancers
- Severe occupational traumatic injuries
- Occupational cardiovascular diseases

The working groups used ideas from the Surgeon General's Report on Health Promotion and Disease Prevention, especially the Canadian Health Field concept, to depict the major elements contributing to unnecessary death and disease. These elements include biologic (e.g., genetic) factors, environmental hazards, human behavioral factors (unhealthy lifestyles), and inadequacies in the existing systems of health care. When applied to problems of occupational health, these elements emphasize that illness or injury in an individual results from both occupational and nonoccupational influences, and that the effects of these influences vary from one individual to another. For example, occupational lung disease stems from environmental exposures to inhalants in the workplaces (dusts, vapors, etc.) and from an important behavioral risk factor—cigarette smoking; the latter not only contributes to the problem, but often potentiates it. Both factors offer important opportunities for preventive intervention.

To conceptualize available preventive measures in a simple way, the working groups used the three broad categories found in “Healthy People”:

- *Health protection* — those actions that prevent environmental hazards; e.g., redesigning equipment or jobs to eliminate hazards.
- *Health promotion* — those actions encouraging people to adopt healthier personal behaviors; e.g., education about the interaction between smoking and environmental exposures.
- *Health services* — those actions to monitor health status, or deliver medical care so as to enhance prevention; e.g., systematic blood pressure measurement.

3. Hamilton A. Exploring the Dangerous Trades: The Autobiography of Alice Hamilton, M.D. Boston: Little, Brown, 1943.

In more than a year of discussions and scrutiny of available information, the working groups developed drafts of the proposed national strategies. The time came for consideration of these drafts by a larger group of professionals, representing various professional viewpoints. Thus, the concept of a National Symposium on the Prevention of Leading Work-Related Diseases and Injuries arose.

The Association of Schools of Public Health (ASPH) learned that we had developed the proposed prevention strategies. Because of their role as a national advocate for public health and prevention, ASPH joined forces with us in sponsoring this major national conference to discuss and improve these draft prevention strategies.

The National Symposium on the Prevention of Leading Work-Related Diseases and Injuries was convened in Atlanta, Georgia, on May 1-3, 1985. It brought together 51 expert panelists, who served as leaders of the five workshops, and over 450 other professionals, representing academia, management, organized labor, professional associations, and voluntary organizations. The five proposed prevention strategies were introduced for discussion, revision, elaboration, and further development. Moreover, a new national vision was introduced—a vision that unsafe working conditions are no longer tolerable and that clear and understandable steps can be taken to prevent the leading occupational diseases and injuries. The proposed prevention strategies that follow are the product of that professional effort. They depict what can be done practically today and also what new knowledge is required to take additional preventive steps toward eliminating the problems.

As shown in each proposed prevention strategy, a first step is surveillance, the gathering of more and better information about what is happening, to whom, and where. Surveillance is needed to accurately estimate the prevalence of each disease or injury on the list. Efforts are needed to identify occupations that are likely to have the highest risks of particular occupational diseases. With this information, specific programs can be developed to reduce the risks in these better defined settings.

New surveillance methods are needed to identify and report problems that are not well defined at present; e.g., specific musculoskeletal injuries and psychologic disorders. Surveillance is needed to identify new occupations and new technologies and to predict their hazards. Such information can establish dynamic profiles that characterize the rapid changes in industry and in occupational safety and health. In all of this, surveillance methods should be carefully evaluated to determine which are the most effective in identifying the populations at risk, in directing the most effective preventive measures to them, and in measuring the impact of prevention.

Next, the strategies focus on scientific research needed to develop the specific knowledge and the understanding on which prevention depends. This means independent science—the right mix of skills, competence, and discipline to deal with new hazards as they emerge. New control measures must be available. These will require innovative research in engineering, design, automation, ventilation, substitution, isolation, and protective changes in work practices, as well as better understanding of the ways in which hazards affect the human systems at the molecular level. Research on control technology must find models to predict workplace exposure before new technologies are designed or installed. New design concepts must incorporate safe methods. The stressors on workers inherent in automated systems require a better understanding of human reaction and adaptation. Research must focus on definitive studies for assessing the causal relation between a particular hazard or task and an injury or disorder. The new science of ergonomics offers the hope of making work truly safe on an unprecedented scale. Research is needed to evaluate the effectiveness of dynamically expanding health promotion programs. Under-

standing the specific interactions between occupational exposures and behavioral factors will assist health promoters to be maximally effective and to focus their attention on the occupational groups that would most benefit.

Training is an integral component of each prevention strategy. Effective communication through information dissemination, education, technology transfer, and training is required to realize the maximum potential of prevention. There is strong evidence that knowledgeable, well-trained workers can avoid injury, even while performing inherently hazardous work. On the other hand, it is no secret that untrained, uninformed workers can be injured even when risks are minimal. As our society transforms its economic base from heavy industry, to service, to information exchange, training will become even more important because of the rapidity of change and our growing dependence on information as a necessary commodity in business. In many industrial processes, computer technology is resulting in change at exponential rates. As new and sophisticated information systems appear in the workplace, workers must either be retrained effectively or must face the uncertain consequences of increased stress. Also, educational efforts need to be directed to the general community in several areas. Medical care establishments must be able to serve the specialized needs of occupational populations. Future engineers and managers must be sensitive to the opportunities for using new technologies to reduce new risks. The public itself must learn to handle quantitative information on risk so as to distinguish the significant from the exaggerated or the trivial.

In all this, the professional in occupational safety and health is crucially important. As Professor Steven Deutsch said in the opening session of the National Symposium, the person who really speaks for workers today is "the occupational safety and health professional." It is the well-informed, well-meaning professional who must serve as a "change agent," attempting to improve working environments, reduce hazards, and develop informed workers, managers, and other citizens. For sustained effectiveness, professionals will have to convince managers and workers that successful prevention requires simultaneous, whole-hearted commitment by labor, management, government, and the community in support of commonly understood and commonly shared goals. They will also have to effectively advocate the truth that prevention is in everyone's best interest.

The proposed prevention strategies presented here will succeed only if they communicate the opportunity and the challenge so well that serious professionals will make them an integral part of their planning and action.

These strategies are proposed for further study, evaluation, and testing, as necessary, but most especially for *use*. It is our hope that the "new vision" presented here will stimulate new dedication and commitment by all of us who are in a position to act. The goal is clear—a dedicated, effective national effort to prevent occupational diseases and injuries.

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A Proposed National Strategy for the Prevention of Occupational Lung Diseases

I. Occupational Lung Diseases: Problems and Goals

The lung is both a target organ and a portal of entry for toxic substances. The likelihood of toxic exposure can be high; for example, an estimated 1.2 million workers each year are potentially exposed to silica dust alone. Early recognition of occupational lung diseases is difficult because the latent period for such diseases may be as long as 15 years for silicosis and 30 years or more for asbestos-related cancers. Other factors, such as cigarette smoking, may contribute significantly to disease processes and hence obscure the association between disease and toxic exposure at work.

The United States Public Health Service has established the following national objectives for the prevention of occupational lung diseases: "By 1990, among workers newly exposed after 1985, there should be virtually no new cases of four preventable occupational lung diseases—asbestosis, byssinosis, silicosis, and coal workers' pneumoconiosis." These four chronic lung diseases will be used as examples in the prevention strategy. To the extent that they are typical of most occupational lung diseases, potential prevention methods available for their control are not unique.

II. Definition and Classification of Occupational Lung Diseases

Occupational lung disease is caused by the inhalation of toxic substances present in the work environment. Lung damage is seldom indicative of the specific injuring agent. Therefore, the recognition of occupational respiratory illness may be obscured by the nonspecificity of symptoms, lung function, radiographic findings, and even occasionally pathologic manifestations. In addition, occupational exposures are often multiple or mixed, symptoms may be minimal until disease is advanced, and latency periods may be long. Work-related lung disease may be further complicated by cigarette smoking and its independent or synergistic effects on the lung. Thus, the association between lung disease and occupational exposure is not always apparent or simple.

Classification of occupational lung disease represents an attempt to provide meaningful associations from available information. From the perspective of disease prevention, perhaps the most useful means of classification is by type of exposure (Table 1.). This scheme permits the rapid identification of toxicants and illustrates the spectrum of their diseases. By categorizing substances in this manner, the applicability of available control technology can be readily addressed. Consistent with this approach, the four diseases identified in the 1990 Objectives (asbestosis, byssinosis, silicosis, and coal workers' pneumoconiosis) would be classified by exposure (asbestos, cotton dusts, silica, and coal dust). This document will use the exposure classification scheme.

Table 1. Examples of Occupational Lung Diseases

Agent	Examples of Agents	Disease/Response
Inorganic Dusts	Crystalline silica	Silicosis*
	Asbestos	Asbestosis*, lung cancer, mesothelioma
	Coal dust	Coal workers' pneumoconiosis*
Organic and Metallic Dusts	Cotton, flax, hemp	Byssinosis*
	Proteins, metallic salts, antibiotics, chemicals (TDI, TMA)	Occupational asthma
	Moldy hay, grain, sugar cane, contaminated humidifiers	Hypersensitivity pneumonitis
Gases and Fumes	Nitrogen, CO ₂ , CO, methane, H ₂ S, NH ₃ , SO ₂ , phosgene, ozone	Asphyxiation, irritation, pulmonary edema
Viable Aerosols	Bacteria, viruses	Brucellosis, psitticosis, anthrax, mycobacterioses
	Fungi	Histoplasmosis, aspergillosis, coccidioidomycosis
Respiratory Carcinogens	Arsenic, asbestos, chromium, radon daughters, nickel, coke oven emissions	Lung cancer*

* — Identified in PHS 1990 Objectives

III. Background for Asbestosis, Byssinosis, Silicosis, and Coal Workers' Pneumoconiosis

Specific examples will be given for the four occupational lung diseases identified in the Public Health Service 1990 Objectives: asbestosis (asbestos), byssinosis (cotton dusts), silicosis (silica), and coal workers' pneumoconiosis (coal dust) by exposure agent.

A. Asbestos

The spectrum of asbestos-related diseases includes nonmalignant fibrogenic effects on lung parenchyma and pleural plaques, together with malignant neoplasms of the lung and serosal linings of the chest and abdomen (mesothelioma). The latent period is 15 years or more for asbestosis and 20 to 40 years for malignancies. The combination of smoking and exposure to asbestos significantly increases the risk of lung cancer. The complexities of the natural history and pathogenesis of asbestos-related diseases pose formidable obstacles to effective surveillance and control. The long latency period associated with asbestosis and malignancies indicates that disease observed today and in the next several decades is the result of past exposures.

The success of intervention measures instituted now cannot be evaluated for many years. Such assessments will be reliable only if medical and environmental surveillance mechanisms are complete and lifelong. The synergistic effect of smoking on lung cancer risk requires alteration of personal habits (smoking cessation) as an integral part of a prevention strategy for asbestos-associated disease.

B. Cotton Dusts

Byssinosis is characterized by both acute (reversible) and chronic lung disease caused by inhalation of cotton, flax, or hemp dusts. Byssinosis is largely preventable by limiting human exposure to cotton dust. Major improvements in dust control have occurred over the past decade in much of the cotton textile industry in the United States. However, even at very low concentrations of cotton dust, a considerable proportion of cotton textile workers may be at risk of developing byssinosis.

Strict control of dust should be supplemented by periodic medical examinations to identify affected individuals and to remove them from dust exposure. This can largely prevent chronic respiratory disease. Identification of the specific causal agent(s) in cotton dust is essential if more effective standards and control measures are to be instituted. The development and cultivation of varieties of cotton plants (and other vegetable fibers) with low "byssinogenic" activity could also substantially reduce the occurrence of byssinosis.

C. Silica

Although the effects of exposure to free crystalline silica have been known for centuries, the prevalence of disabling acute and chronic silicosis (nodular pulmonary fibrosis) remains high in certain groups of workers (workers in mines, stone quarries, sand and gravel operations, foundries, abrasive blasting operations, and glass manufacturing). Because silica is one of the most abundant minerals in the earth's crust, exposures are likely to occur, often without being recognized. When such exposures are recognized, it is possible to prevent the disease by controlling the environment. Because of the latency of chronic silicosis, the lack of effective treatment, and the progression of disease even after exposure has ceased, *prevention of exposure* is the most important strategy. Technologies for controlling silica-containing dusts are well developed for most industries, but often these control measures are either not applied or are not widely known.

D. Coal Dust

Several studies showing a clear dose-response relationship between coal dust exposure and the development of simple coal workers' pneumoconiosis (CWP) indicate that the complicated form of the disease can be prevented if dust exposure is sufficiently reduced. Reduced levels of CWP in recent years, under lower dust standards in both Great Britain and the United States, illustrate that prevention of the disease is a realistic goal from both technical and economic viewpoints. The data also suggest that if primary prevention is unsuccessful and a worker is detected with early simple CWP, serious disabling disease can still be prevented by moving the worker to a lower-dust environment.

IV. Occupational Lung Diseases Prevention Strategy

A. Preventive Components: What We Know and Can Implement Now

1. Agent-Oriented Strategies

a. Environmental Hazard Surveillance

Efforts should be continued to identify occupations in which workers are likely to have a high incidence of occupational respiratory disease. Special attention should be given to environmental surveillance and exposure control. Environmental surveillance is the most effective means of identifying problem areas, directing control efforts, and subsequently measuring the impact of prevention strategies.

i. Asbestos

Occupations where workers are likely to be at high risk of exposure to asbestos (such as asbestos removal operations) need to be identified. Special attention should be given to environmental surveillance and control of such occupations.

ii. Cotton Dusts

Industries using cottons that contain high levels of endotoxins should be identified and evaluated for possible additional intervention strategies or enactment or enforcement of a more stringent dust standard.

iii. Silica

Occupations likely to have a high incidence of silicosis could be identified through Standard Industrial Classification (SIC) codes; lists of industries that manufacture silica products; and data from the Mine Safety and Health Administration (MSHA), the Occupational Safety and Health Administration (OSHA), the Bureau of Labor Statistics (BLS), the Bureau of Mines (BOM), the National Center for Health Statistics (NCHS), the National Occupational Hazard Survey (NOHS), National Occupational Exposure Survey (NOES), and the National Occupational Health Survey of Mining (NOHSM). The need for increased environmental surveillance and exposure controls in, for example, the industrial sand industries and foundries, is already

known. Any worksites (such as coal mines) where silica levels exceed the standard must be identified, and the silica standard must be enforced by the Mine Safety and Health Administration.

b. Medical Hazard Surveillance

Disease surveillance is needed to estimate the prevalence of occupational lung disease. However, because of the latency, the lack of treatments, and the progression of some occupational lung diseases after exposure has ceased, disease surveillance to identify exposures is of limited practical value, and emphasis should be placed on environmental surveillance.

Several data sources for disease surveillance exist, such as disability/impairment (workers' compensation) data, insurance data, company surveillance data required by OSHA, company surveillance data voluntarily collected by industry, and state reporting systems.

Hospitals are another potential source of data and should be required to record work histories and to report occupationally related diseases in their discharge reports. State reporting systems using local physicians and county health officers are potentially the most effective means of disease surveillance. The primary advantage of using local physicians and county health officials is their familiarity with local industry and the medical community. Involvement of local county health departments would also facilitate follow-up of reported cases. However, this surveillance method has several difficulties, the most significant being the reluctance of physicians and workers to report diseases because of the potential for litigation and reprisals. Crucial to the success of such reporting systems would be clear diagnostic criteria (case definitions) and physicians who can recognize patients with diseases related to their work environments.

c. Hazard Removal

For many hazardous substances, control measures are difficult or unavailable. However, substitute materials are often available for the hazardous substances and should be used.

i. Asbestos

A rule-making change should be undertaken by OSHA to require that a dust control and monitoring plan for *all* operations with likely asbestos exposure be filed for approval *before* any work is done on the site. Implicit in this requirement would be a sound justification for the use of asbestos as opposed to alternative materials. Nonessential uses would not be approved. In addition, existing construction standards and codes should permit noncarcinogenic substitutes, especially where asbestos is recommended as an insulator by Underwriters Laboratories (UL) and building codes (both electrical and mechanical).

ii. Cotton Dusts

Because different grades of cottons and cottons from different regions have been shown to cause significantly varied acute responses in human subjects, industries in which workers show acute reactions at

dust levels below $0.2\text{mg}/\text{m}^3$ should consider the use of cotton substitutes or lower dust levels. Cotton substitutes include high grade cottons, blends of high and low grade cottons, cottons which have been washed, and synthetic cotton substitutes.

iii. Silica

Because effective controls for silica in abrasive blasting operations have not been demonstrated, silica should be banned as an abrasive blasting material; this was done in Great Britain over 30 years ago. Available silica substitutes that have been shown to be nontoxic should be used.

2. Exposure-Oriented Strategies

a. Control Technology

Many exposure control measures are available, such as engineering design and automation, ventilation, substitution, isolation, and changes in work practices. Implementation of the Atomic Energy Commission—As Low As Reasonably Achievable (AEC ALARA) levels should be considered in highly hazardous processes. Technology transfer and implementation goals should be established, so that both workers and management are familiar with control technology and its application. Specific effort should be made to ensure that technology transfer is a two-way process in which the success of implementing new technology is assessed at periodic intervals. Efforts should be made to reach small operations that may not have access to new technology information.

b. Regulatory Enforcement

Regulatory enforcement is the most effective element in the strategy to prevent occupational lung disease. The Mine Safety and Health Act and the Occupational Safety and Health Act both place the responsibility for providing a safe and healthful workplace squarely on the shoulders of the employer. Other measures of enforcement include sampling requirements for operators, an inspector “audit” program, pre-operation filing of hazard control plans, and the right for inspectors to stop unsafe operations onsite. Also, MSHA and OSHA should establish a framework for technology transfer to help operators come into compliance and to educate management, safety personnel, and the workers themselves.

i. Asbestos

Evidence indicates that the current asbestos standard provides only partial protection from asbestos-related diseases, particularly cancer. The present permissible exposure limit (PEL) should be reduced to the NIOSH-recommended concentration of $100,000\text{ fibers}/\text{m}^3$ since that is the lowest level of exposure that can be accurately measured using currently available analytical techniques.

ii. Silica

Silicosis continues to be a problem because exposures above legal

limits continue to occur. This situation exists both where the overexposures are well documented by companies, states, and federal agencies, and where silica exposures are not recognized. Once exposure is recognized, control could be accomplished in practically every instance through engineering controls or substitution. The most effective preventive measure for silicosis is preventing hazardous exposure, through *strict enforcement of an appropriate exposure standard*. Present federal standards, based on percent silica, range from allowable exposures of 33 $\mu\text{g}/\text{m}^3$ to 98 $\mu\text{g}/\text{m}^3$ free silica. These levels should be unified to a single standard that provides protection against silicosis over a working lifetime.

iii. Coal Dust

The most effective prevention strategy for CWP is to continue the present efforts with some improvements. NIOSH data suggest that the incidence of CWP is declining, probably due to the 1970 standard (2 mg/m^3 with medical monitoring). In addition, efforts should be made to increase the awareness of dust-control techniques among small-scale operators. Texts that are easy to understand are needed on the latest and most effective control techniques.

c. Education and Training

An education program must be targeted to future engineers and managers to increase the appropriate use of control technologies. Intervention should be directed toward schools of engineering, public health, business, and vocational education. Successful exposure control techniques, once demonstrated at state and local levels, could be distributed nationally. The occupational health professional must also be appropriately trained and actively involved as a "change agent" in trying to improve working environments and developing informed worker and management groups.

The educational program of occupational health professionals should include special emphasis on epidemiology, biostatistics, industrial hygiene and safety, toxicology, and occupational health. The professional needs to learn what the work environment is, how to assess work exposures, and how to control them. The proper use of engineering controls and personal protective devices is a necessary component of such education.

For sustained effectiveness, training should emphasize the need for simultaneous involvement of management, occupational health professionals, production personnel, and workers, if occupational health programs are to be successful. Indeed, a successful program presupposes workers who are informed about work hazards and safe work practices and are encouraged to work cooperatively to reduce hazards. Such programs must be tailored to small, medium, and large workplaces.

State and local health departments can offer a ready source of expertise (physicians, nurses, sanitarians, epidemiologists, and others). These departments and primary care physicians should be used to identify small and local plant problems. Primary care physicians should be taught to recognize work-related diseases as part of their routine medical training.

d. Incentive Systems

Although workers' compensation laws do provide some financial relief for disabled workers, they are essentially applied only after existing prevention systems have failed and when physical remedies are nonexistent. For this reason, and because the individual state compensation laws are diverse, significant modifications to the present system will not be achievable as part of a prevention strategy.

Because many exposures occur without the health consequences being known, manufacturers should promote increased awareness of the hazards associated with the use or improper use of hazardous materials by labeling products and issuing warnings. This prevention mechanism is particularly important for workers employed by small companies that use silica and asbestos products.

Economic incentives, such as lower insurance premiums, should be explored as a means for industry to implement new controls.

The authority of federal mine inspectors to "red tag" (shut down) a section of a coal mine if the hazard is severe, life-threatening, or caused by the "unwarrantable failure" of the operator to comply with mandatory safety or health standards, is an example of a powerful incentive for compliance that should be continued.

e. Respirators

Respirators and other personal protective devices should not be considered a primary control mechanism because they rely on human intervention. Recent studies have indicated that, under actual working conditions, respirators may not provide a level of protection equal to that determined in laboratory tests.

3. Worker-Oriented Strategies

a. Health Promotion and Smoking

Smoking is strongly associated with many lung diseases, including chronic bronchitis, emphysema, and lung cancer. Moreover, smoking has an additive effect on the risk for chronic bronchitis in workers exposed to coal mine and other dusts, and it acts synergistically with asbestos to increase the risk of lung cancer. Evidence also indicates adverse health effects on those who are exposed to the smoke of others. Because of the overwhelming evidence of the dangerous health consequences from smoking and the number of workers affected, a focus on smoking is an important component of a prevention strategy.

As Dr. Charles Carrington, past Chairperson, Mine Health Research Advisory Committee (MHRAC), said, "To attempt to control lung diseases without addressing smoking is so naive as to appear ludicrous." (MHRAC meeting, 1983). Elimination of smoking in the workplace is thus an important strategy, and one that supports the Surgeon General's goal of a smoke-free society in the United States by the year 2000.

The most prudent approach would be state legislation against smoking as it contributes to indoor air pollution, rather than specific laws against smoking in the workplace. Such state laws could designate all public places as nonsmoking areas, and management could then declare the company a "public place." Regardless of legislative outcome, management and labor should work together to develop appropriate nonsmoking policies that include some or all of the following:

- Prohibit smoking at workplaces, with sufficient disincentives for those who do not comply.
- Distribute information on health promotion and the harmful effects of smoking.
- Offer smoking-cessation classes to all employees at no cost to the participant. Smoking is addictive, and to prohibit smoking without offering this assistance to the smoking employee would be unjust.
- Establish incentives to encourage employees to stop smoking. For example, distribute to nonsmoking employees a portion of savings realized from smoking cessation (fewer lost workdays and lower health care and disability costs).

NIOSH will demonstrate its leadership in this area by adopting a model strategy within the Institute.

Note: Smoking in conjunction with exposure to asbestos could be addressed as part of a general health risk appraisal program, such as in the Centers for Disease Control software for Health Risk Appraisal. Considering the synergism between smoking and exposure to asbestos, a ban of workplace smoking and aggressive smoking cessation programs are warranted for workers exposed to asbestos.

b. Worker Knowledge of Exposure and Control Measures

Workers should be specifically informed of the hazards to which they are exposed and the control measures available. This should be accomplished by employers distributing information to employees and by public education at the secondary school level. Industries using hazardous substances, such as ground silica (silica flour), where acute and rapidly progressing cases of silicosis have been found, should be required to distribute information to their workers on an "action level" dust control performance measurement. Worker right-to-know laws should be enacted to ensure that workers exposed to hazardous substances, such as silica and asbestos, are informed and aware of the importance of control measures.

c. Disease Surveillance

Medical surveillance described previously to identify unsafe exposures and estimate disease prevalence was oriented toward the agent. Disease surveillance oriented toward the worker is designed to discover those workers who may be at increased risk if exposure continues. This increased risk may result from a pre-existing condition, early development of disease, or hypersusceptibility to a particular agent. When these

workers are identified, some form of intervention is warranted, usually involving a reduction of further exposure.

i. Cotton Dusts

A key secondary prevention strategy for byssinosis has been the identification of workers with acute reactions to cotton dusts or reduced ventilatory function. The rationale for this medical surveillance is to prevent development of chronic respiratory disease by identifying workers with acute reactions and preventing further exposure.

ii. Coal Dust

A secondary prevention strategy for coal workers' pneumoconiosis is the use of the chest radiograph to identify miners with simple CWP. Once identified, these miners are given the option of working in a low-dust environment to prevent progression of simple CWP to the disabling, complicated CWP.

B. Preventive Components: What Knowledge Do We Need

1. Agent-Oriented Strategies

a. General Recommendations:

The toxicity of new substitute materials should be evaluated before they are introduced into the workplace—for example, silica substitutes.

Methods should be developed to determine relative causality in carcinogen exposure. Currently, causal factors cannot be separated or probabilities predicted because of insufficient knowledge about carcinogenic mechanisms.

A simple, inexpensive, and rapid method for determining airborne concentrations should be developed to enhance environmental surveillance for and control of exposure to several agents (silica and asbestos).

b. Specific Recommendations:

Cotton Dusts

The exact etiologic agent(s) of byssinosis are unknown, and thus efforts are thwarted to either cultivate or process cotton to remove such agent(s). Further research is needed to better define the specific agent(s) so that more effective control and exposure standards can be developed. For example, once an etiologic agent has been identified, it may be possible to more effectively control exposure, possibly by blending contaminated and uncontaminated cotton to lower exposures to this agent.

Silica

Current MSHA and OSHA environmental data should be evaluated to develop more effective means of identifying those sites where workers may develop silicosis. Within various industries identified as likely to have

a high incidence of silicosis, specific sources of exposure must be identified before control techniques can be applied. This will involve detailed surveys of each suspected industry and processor. Some evidence, for example, shows that crushing may selectively break and aerosolize the silica fraction of the ore. An awareness of basic facts like these is needed before effective control measures can be developed.

For medical surveillance to be effective, an operational definition of silicosis is needed to standardize the diagnosis of silicosis reported to a surveillance system.

Coal Dust

Better sampling strategies and methods are needed for underground and surface mines, including mine surveillance, assessing personal exposure, and evaluating the effectiveness of technology.

2. Exposure-Oriented Strategies

a. General Recommendations:

Research on control technology for new applications and methods should be continued. Alternative approaches to process engineering controls are essential. For example, a worker's exposure may not be related to the primary worksite but to intermittent dust sources, such as roadways, stockpile, agricultural fields, or dust collector discharges. Traditional engineering approaches have not always been effective in controlling these sources.

Control technologies and strategies must be promoted through education and incentive programs. The best methods to implement and administer such programs are needed.

Predictive models to determine workplace exposures need to be developed before design or installation of process equipment.

If current standards for an agent are nonexistent, or if the exposure-response data are incomplete, additional research may be needed to develop more effective exposure standards.

b. Specific Recommendations:

Asbestos

The exposure-response for asbestosis and the effects of fiber types in the disease process need to be ascertained.

Research is needed to determine the potential health benefits and the risks of asbestos-removal programs in office buildings and schools.

Since significant new exposures may occur when old structures are renovated or demolished, control should be evaluated for asbestos-removal operations. Effective asbestos-removal work practices are needed.

A quantitative method should be developed to determine the fiber release potential of in-place friable asbestos materials. The method should then be incorporated into a "control options" assessment strategy.

Cotton Dusts

Protective standards with strict enforcement by OSHA are essential to prevention of byssinosis. Once the specific causal agent(s) of byssinosis has been adequately identified, the effectiveness of the current dust standard should be evaluated.

New efficient and effective means of removing or controlling the specific causal agent(s) of byssinosis will be needed when the agent(s) has been identified.

Silica

The dose-response relationships for silica and silicosis need to be determined, particularly for low levels of exposure and exposure to mixed dusts containing silica.

Coal Dust

The use of longwall mining techniques is increasing in the United States, and improved dust control technologies are needed. In addition, new technologies are needed for control of silica dust on sections using continuous mining equipment, particularly those operating at reduced standards. For all mining methods, forecasting and predictive techniques should be established, and specific means of implementing control technology into mine planning and equipment design should be developed.

Because productive mining methods of the future may generate more dust at the increased rate at which coal is broken, specific long-range strategies for control technology should be developed, and directed basic research should be conducted to support these strategies. For example, the fundamental mechanisms by which dust is generated and transported must be understood and joined to specific control technology objectives. Also, respirable dust characteristics should be correlated to coal seam and mining methods.

3. Worker-Oriented Strategies

a. General Recommendations:

More sensitive techniques need to be developed for detecting early changes at the cellular level and for recognizing very early signs of disease. Methods are also needed to predict susceptibility to occupational asthma or the organic dust diseases. For example, are workers who react acutely to organic dusts more susceptible to long-term effects?

Because the current literature is not consistent about the relationship between smoking and diffuse lung fibrosis, research is needed to determine whether smoking influences this disease process.

Research is needed to determine whether serious effects result from low-level, but episodic, exposures to irritant gases and fumes, and whether long-term effects follow acute responses to pulmonary irritants.

The scope of the hypersensitivity pneumonitis problem needs to be determined.

b. Specific Recommendations:

Asbestos

Dose-response relationships for asbestosis and pleural changes require better definition. Estimates of risk for asbestosis and asbestos-related cancer are needed for low doses, intermittent exposures, and short-term, high exposures. The health effects of "short" asbestos fibers and the relationship between asbestos exposure, pleural changes, and the development of lung cancer should also be studied. Information on the relative pathogenicity of different asbestos types and asbestos substitutes should be refined. The significance of pleural plaques to mortality and morbidity needs to be determined.

Cotton Dusts

The current status of medical surveillance as mandated by the Cotton Dust Standard must be assessed. A clear relationship between acute responses and chronic respiratory disease in cotton workers has not been established, and a prospective study is necessary to investigate this relationship. New NIOSH recommendations may be necessary to make medical surveillance for cotton workers more effective in preventing chronic respiratory disease. In addition, little published information is available on the normal decrements in lung function to be expected annually. The lack of this information has made interpretation of lung function data for cotton workers less effective. More information is needed about host risk factors, such as smoking and atopy. These risk factors, along with medical surveillance, can be used to identify the workers most at risk of developing chronic respiratory disease.

Silica

Because several animal and epidemiologic studies have raised the question whether quartz is a carcinogen, further well designed epidemiologic studies are needed to determine whether this is true.

Coal Dust

Because some disabled miners have no radiographic evidence of CWP, the severity of nonpneumoconiotic lung disease (bronchitis and emphysema) in coal miners and its relationship to dust level, composition, and size distribution need to be investigated. Research into the dose-response and lung function relationships of dusts and acute and chronic bronchitis should be conducted with the goal of setting a total dust regulation for general industry as well as for underground coal mines. Better long-term studies of both miners and ex-miners are needed to accurately assess the totality of adverse health effects from dust exposure in coal mining. The

relationship of coal dust exposure to the development of emphysema also needs to be resolved. Only with such knowledge can we intelligently attack all work-related pulmonary diseases in miners.

V. Summary

This prevention strategy will not succeed or fail on the basis of any one of the elements described. All elements must be addressed if occupational lung diseases are to be prevented. For example, problem areas can be identified through environmental and medical surveillance; however, without follow-up and corresponding elimination or reductions in exposure, surveillance would be of little practical value.

Surveillance must be coupled with exposure control (e.g., exposure standards with strict enforcement, work practices, automation, ventilation, incentive systems) and other important elements described in this prevention strategy. Health promotion and the development of a workplace smoking policy, while not always directly related to occupational exposures, are additional important elements.

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A Proposed National Strategy for the Prevention of Musculoskeletal Injuries

I. Musculoskeletal Injuries: Problems and Goals

The Surgeon General's Report on Health Promotion and Disease Prevention in 1979 adopted the Canadian Health Fields Model (HFM) as a useful concept for identifying the elements that contribute to death and disease. Four elements were identified:

- Environmental hazards
- Human biologic factors
- Behavioral factors or unhealthy lifestyles
- Inadequacies in the existing health care and ancillary systems

The Surgeon General originally used this model to analyze the ten leading causes of death in 1979. By analyzing the risk posed by each element, the Surgeon General concluded that the prevalence of many diseases could be reduced if the Nation focused on preventive activities; i.e., reducing hazards and avoiding unhealthy lifestyles.

When applied to problems of occupational health, the health field model emphasizes that an individual's illness or injury is the result of several occupational and nonoccupational influences; these influences differ among individuals. The elements can also be applied to work-related musculoskeletal injuries, and each element offers an opportunity for prevention:

- A. Environmental Hazards: Hazards to the musculoskeletal system associated with work are described as workplace traumatogens. A *traumatogen* is defined as a source of biomechanical stress stemming from job demands that exceed the worker's strength or endurance, such as heavy lifting, or repetitive, forceful manual twisting. Traumatogens can be measured by determining the frequency, magnitude, and direction of forces required in relation to body posture and the point of application.

- B. **Human Biologic Factors:** These include the anthropometric or innate attributes that influence a worker's capacity for safely performing the job. Examples include the worker's physical size, strength, range of motion, work endurance, and the integrity of the musculoskeletal system. These factors partly account for variability in performance capability in the population and the potential mismatching of worker and job. Hence, when job demands habitually exceed the worker's capacities as defined by such physical attributes, the health and safety of the worker are compromised.
- C. **Behavioral Factors or Unhealthy Lifestyles:** This element refers to acquired behaviors or personal habits that increase the worker's risk of incurring musculoskeletal strain or injury. Such behavioral factors may include insufficient sleep or recovery from exertion, the perception of the job as being excessively demanding or hazardous, job dissatisfaction, and mental lapses due to response interference. Lifestyle factors can include obesity or lack of adequate physical fitness, unhealthy diet, and substance abuse either during or outside work. Recent studies have also focused on personality factors predictive of permanent disability.
- D. **Inadequacies in the Existing Health Care and Ancillary Systems:** These factors include a lack of medical knowledge and appropriate training for health care personnel on the etiology, diagnosis, and treatment of musculoskeletal problems that result from biomechanical strain. Management, design engineers, and workers need special health and safety training in recognizing traumatogens and in understanding the role of biologic and behavioral risk factors for musculoskeletal injuries. Such groups would also benefit from training in the principles of prevention and health promotion.

II. Conditions to be Addressed

The National Institute for Occupational Safety and Health (NIOSH) has identified work-related musculoskeletal injuries as one of ten leading occupational health problems affecting workers. Musculoskeletal injuries as considered here encompass both acute and chronic injury to muscles, tendons, ligaments, nerves, joints, bones, and supporting vasculature; injury is understood as a component of the overall classification, disorder. Descriptive examples of the term injury include sprains, strains, inflammations, irritations, and dislocations. In contrast, mishaps resulting in injuries in which the skin or bones are broken, such as from the transfer of high energy, are defined as traumatic injuries. These occupational traumas are the subject of the Proposed National Strategy for the Prevention of Severe Occupational Traumatic Injuries.

Injury resulting from exposure to continued trauma is often defined according to the structure thought to be inflamed, irritated, or strained, for example, tendonitis, synovitis, bursitis, nerve entrapment, and lumbar pain. Collectively these terms are applied to a broad class of physical symptoms or complaints that are commonly labeled in the medical literature as wear-and-tear disorders, overuse injuries, osteoarthritis, degenerative joint diseases, chronic microtraumas, and cumulative trauma disorders.

Because few of the musculoskeletal injuries that stem from exposure to long-term trauma are universally accepted as uniquely occupational in origin, defining a work-related musculoskeletal injury often depends on identifying a hazardous antecedent condition in the workplace.

Much remains to be learned about the causes for work-related musculoskeletal injuries. A current theory holds that continued exposure to excessive physical stress accelerates the onset or aggravates the course of regional musculoskeletal injuries. Indeed, the sources of the high physical stress can often be traced to ordinary work activities that include repetitive or sustained lifting, bending, twisting, climbing, reaching, gripping, pinching, rubbing, kneeling, and squatting as well as vibration from equipment. Moreover, these activities are often performed in awkward postures and involve high forces. When the job demands inherent in these activities repeatedly exceed the biomechanical capacity of the worker, the activities become trauma-inducing. Hence, traumatogens are workplace sources of biomechanical strain that contribute to the onset of injuries affecting the musculoskeletal system.

The difficulty in discovering the etiology of this class of regional musculoskeletal injuries parallels the difficulty in defining the mechanism responsible for the symptoms. One notion is that the accumulated microtrauma caused by repetitive motion can set up a symptomatic inflammatory response, which may in turn be responsible for the symptoms and the restricted motion associated with aging. Furthermore, if the accumulated microtrauma is not given enough time to heal, a secondary risk of tissue failure may result. This process may account for conditions such as tendon ruptures or even stress fractures. Similar outcomes may occur in response to single traumas or to a few exposures to extremely high levels of biomechanical stress. Such postulates, however, are heuristic when applied to many common regional musculoskeletal injuries where no demonstrably pathoanatomic abnormalities can account for the symptoms. Regardless of the cause, abnormal anatomy, physical fitness, previous injury, or age-related changes can also alter one's physical capacity and thus can contribute to the injury.

III. Scope of the National Problem

Our present knowledge of the national scope of work-related musculoskeletal injuries is clearly inadequate, providing at best a limited and fragmented view of the extent of such problems. A main reason is that current estimates of the problem have been extracted from existing data bases that were not designed for the surveillance of occupational musculoskeletal injury. As such, the existing reporting systems confound occupational- and nonoccupational-related disorders, fail to differentiate chronic and acute injuries, and lack standard terminology and diagnostic criteria for defining cumulative trauma-related musculoskeletal disorders.

Despite the absence of accurate national prevalence data, there is a growing awareness among researchers and practitioners that musculoskeletal injuries account for a highly significant amount of human suffering, loss of productivity, and economic burden to the country. Support for these views comes in part from the following sources:

- Musculoskeletal injuries are the leading cause of disability of people in their working years, afflicting 19 million persons (National Center for Health Statistics, Health Interview Survey, 1977). High risk industries include manufacturing, construction, and food processing. Nearly one-half the Nation's workforce are affected at some time during their working life.
- Musculoskeletal injuries rank first among health problems in the frequency with which they affect the quality of life, as indicated by the extent of activity limitation (National Center for Health Statistics, Health Interview Survey, 1977).

- The cost of musculoskeletal injuries, based on lost earnings and worker-compensation payments, exceeds that of any single health disorder. Low back problems alone cost American industry an estimated \$14 billion per year (1976).
- Musculoskeletal injuries account for one-third of annual worker compensation claims. Claims for sprains and strains are the most prevalent—with the back accounting for almost 50 percent of such disorders—followed by disorders of the ankle, knee, and shoulder.
- Musculoskeletal injuries also represent a significant accessory or causal factor in a large number of acute traumatic injuries.
- The frequency and impact of musculoskeletal conditions on the workforce are expected to increase over the next several decades as the average age of the workforce increases.

A projected increase in musculoskeletal injuries and disorders is already evident despite the move toward more sophisticated automation and the shift away from physical to mental work, for example, processing of information and service-related jobs. Remarkably, the introduction of modern office technology, such as computers, video display terminals, and optical scanners, designed to reduce physical labor, has generated claims of new, pervasive, and even more insidious sources of biomechanical stress to the musculoskeletal system. The majority of these claims are attributed to chronic repetitive motion and static and constrained postures. The magnitude of these problems is only now beginning to emerge.

IV. Potential for Prevention and Control

Prospects for reducing work-related musculoskeletal injuries depend on progress in four methodologic areas.

- Identifying accurately the biomechanical hazard.
 - Developing effective health-promotion and hazard-control interventions.
 - Changing management concepts and operational policies with respect to expected work performance; i.e., working smart, rather than working hard.
 - Devising strategies for disseminating knowledge on control technology and promoting their application through incentives.
- A. Determining the causes of musculoskeletal injuries continues to be problematic, as with all disorders associated with trauma and aging. This difficulty results partly from the complexity and number of potential etiologic factors, the long latency periods, and the interaction with the effects of aging. Moreover, no standardized set of diagnostic criteria and techniques or medical signs and symptoms is yet available to reliably identify many of the disorders. More vigorous and focused longitudinal research is needed to identify occupational and nonoccupational causes.
 - B. Developing interventions has a practical, problem-solving focus. The recommended interventions for reducing work-related musculoskeletal injuries involve an engineering approach; i.e., redesigning the work process or tool to impose less

biomechanical stress. Without complete information on causes, reasonable assumptions must be made based on biomechanical models of physical trauma so that answers to problems can be tested by judging both their feasibility and effectiveness.

Information is already available from ergonomics and allied fields to suggest that many of the biomechanical hazards associated with occupational musculoskeletal injuries could be eliminated if such knowledge were put into practice. Field validations of biomechanically based prevention strategies are needed to determine those that work.

- C. Changing management concepts of productive work is important because managerial concepts and practices often become main contributors to musculoskeletal injuries. Many jobs enter the high-risk category because demands for production put pressure on supervisors to “get things moving.” Like football coaches, many managers are convinced that a 125 percent effort is better than an 85 percent effort. However, this work ethic may not be valid for certain tasks. Managers who establish operating policies, such as “working smarter is better than working harder,” in the worker’s mind, may most effectively maintain production levels by reducing lost time due to worker injuries. However, unless workers understand this policy, little chance exists to improve the cautionary responses needed for prevention.
- D. Dispensing and applying accumulated knowledge is essential for overcoming resistance to change and reconciling the initial costs of proposed interventions with anticipated long-term benefits. The disparity of backgrounds of key professional people who must cooperate in advocating and evaluating interventions must also be overcome. For example, in the musculoskeletal area most engineers are not trained in ergonomics or biomechanics and health care personnel are not knowledgeable about manufacturing technologies, yet they must work together. The problems in cooperation common to all health and disease-prevention programs are now being recognized as most formidable and potentially the chief roadblock in any prevention-oriented program. Probably the most direct approach to this issue is to fund targeted, controlled, intervention trials. Resistance to change might fade in the face of substantial data.

Despite these difficult issues, the Nation cannot ignore this growing occupational health problem or the significant volume of information on musculoskeletal injuries emanating from such fields as biomechanics, clinical research, and ergonomics. Hence, a first national strategy is offered for preventing or reducing the incidence of work-related musculoskeletal injuries and disorders.

V. Addressing Broad Tactical Areas of a National Strategy for Prevention

A. Refining Surveillance Systems

1. Health Surveillance

Strategies designed to prevent or mitigate musculoskeletal injuries require sensitive and verifiable surveillance schemes for identifying and reporting specific musculoskeletal conditions. Such systems should provide an analysis by occupation to target those occupations that display disproportionate incidence. New occupations and emerging technologies in which workers may be at risk from exposure to unprecedented biomechanical stresses also need to be identified.

Existing data clearly indicate major deficiencies in surveillance systems for identifying work-related musculoskeletal injuries. Because existing data sources were not designed for surveillance of occupational musculoskeletal injury, they do not separate chronic from acute injuries, and they lack a standard terminology for defining the acute and chronic medical conditions in general.

2. Hazard Surveillance

Coupled with needed refinements of health surveillance is a similar need for improved surveillance to define the types and ranges of biomechanical stresses that exist in the workplace. The ultimate value of hazard surveillance lies in prevention because it can provide an early warning of potential cumulative trauma.

Hazard surveillance would make use of ergonomic-type surveys, worksite inventories, or biomechanical profiles of various job conditions to identify the types of biomechanical job demands that pose a risk of musculoskeletal injury. Evidence of workplace-related hazards is particularly important because the hazard may be the only reliable way of classifying a musculoskeletal disorder as work-related.

Without some form of workplace data to identify the presence of biomechanical stress, nonspecific chronic health symptoms, such as joint pain and loss of mobility, may be incorrectly diagnosed as nonoccupational and go unreported. In addition to the obvious value for enhancing the validity of surveillance data, information on sources of biomechanical stress for a given occupation can be used to build models that predict the occurrences of musculoskeletal injuries.

3. Essential Elements for Surveillance of Occupational Musculoskeletal Injuries

- a. Guidelines should be set for data collection and diagnostic criteria established for classifying all musculoskeletal disease conditions experienced by workers, whether job-related or not. Definitions should be standardized for characterizing discomforts, injuries, and hazards.
- b. Objective criteria should be determined to differentiate occupationally from nonoccupationally related disorders. The system should also identify the methods of reporting.
- c. Multilevel data bases at national, state, and local levels should be established and supplemented with specific longitudinal epidemiologic evaluations. Multilevel recording is important because the long induction periods for many of the musculoskeletal injuries separate the hazard from the effect. A multilevel health reporting system could track health status across jobs, across geographic relocations, and through retirement.

In general, a positive byproduct of an effective surveillance program would be the renewed awareness within the medical community of the prevention benefits to be derived from a standard reporting system. Such a system would also assist occupational health providers in correctly diagnosing, recording, and treating musculoskeletal injuries.

Recommendations for improving surveillance systems are given in the section on Action Plan.

B. Evaluating Cause and Effects

1. Coordinating Scientific Disciplines

Ultimately any effective strategy geared to prevention must be based on a firm grasp of the factors responsible for the targeted disorder. Analysis and evaluation of relevant surveillance and clinical data are required to uncover the key occupational and nonoccupational risk factors.

For musculoskeletal injuries, the evaluation stage in the prevention process requires the coordination of research in several disciplines encompassing both basic and applied approaches. For example, health professionals should be encouraged to work with engineers and scientists to develop research programs that incorporate each specialty in the design and implementation of an intervention. Once an intervention is designed, hardware manufacturers and users should be brought into the process to fabricate and disseminate new, ergonomically designed equipment, tools, and workplaces.

One of the more pressing needs is for studies that examine the patterns of interacting variables. Methods and measurement techniques also need standardization and better documentation to allow adequate verification and validation so that practitioners can benefit from the development.

2. Causes of Low Back Pain

Evaluating the etiology of low back pain is particularly difficult. Much of what is known about the risk factors for low back injury is based on epidemiologic data. Two categories of factors that modify the risk of injury have been differentiated from recent surveillance efforts: factors associated with the job and personal factors. Job risk factors include load weight, location, and frequency of materials handling, but often go beyond task design to include psychologic factors. Personal factors emphasize age, gender, and strength, but the significance of other personal factors such as fatigue, postural stress, trauma, emotional stresses, degenerative changes, congenital defects, genetic factors, neurologic dysfunction, physical fitness, and body awareness should also be evaluated. The list is far from complete. These personal factors in combination with primary job risk factors make determination of the cause of low back disorders most formidable.

Nevertheless, research on low back pain has progressed beyond the stage of identifying risk factors to include evaluations involving dynamic and 3-dimensional modeling and laboratory confirmation. Improved techniques are now needed for estimating tissue forces and pressures noninvasively, both in the laboratory and on the job. Such techniques are necessary to evaluate the stress patterns induced during manual materials handling and to determine to what extent they could be eased through varying different load factors or lifting techniques.

3. Causes of Extremity Disorders

Some progress has also been made in isolating key sources of work-related

biomechanical stress for the upper extremities. Biomechanical analyses of hand and arm motions have been useful in specifying points of stress related to symptoms of carpal tunnel syndrome and tenosynovitis. Repetition rate, amount of force required, and postural factors emerge as contributors to these injuries.

In contrast, research on occupational injury of the lower extremities has been limited almost exclusively to the knee. Potential sources of biomechanical trauma to the knee that have been identified include repetitive loading, constant kneeling, squatting, and repetitive contact between the knee and specialized tools.

In general, continued research is needed to combine anatomic, mechanical, physical, and human factors in describing work populations by their abilities to work on a given task without injury. These profiles would provide guidelines for designing new jobs and tools to protect the limbs and joints from excessive biomechanical stress.

Recommendations for improving our understanding of causal mechanism are listed in the Action Plan.

C. Controlling Occupational Risk Factors

Three approaches are used for intervention in jobs in which high physical demands pose a risk to the musculoskeletal system.

- Redesign the job or tools so that demands can be met by a majority of the population.
- Train workers in techniques to reduce job hazards; i.e., how to lift and how to avoid awkward postures and repetitive motions.
- Select only those individuals whose work capabilities meet or exceed the high demand.

1. Ergonomic Job/Tool Redesign

a. Operating Principle

The use of engineering techniques has been a basic tenet of occupational safety and health practice for achieving hazard control, in preference to other methods, such as personal protective equipment and safe work practices, which are less reliable and often less effective. The engineering procedure involves modifying task and tools using ergonomic principles to reduce the effects of biomechanical stress.

Unlike the majority of occupational hazards, sources of biomechanical stress seem hidden within the job as specialized patterns of movement or tool use. The relative obscurity of the hazards necessitates that controls be designed into each job identified as having a high risk of musculoskeletal injuries.

This ergonomic approach is based largely on the assumption that work activities that involve less force, repetition, vibration, weight, and forms

of static or constrained postures are less likely to cause injuries and disorders. The approach is desirable because it seeks to eliminate potential sources of problems. Ergonomics also seeks to make safe work practices a natural result of the tool and worksite design without depending on specific worker capabilities or work techniques.

b. Difficulties Associated with Ergonomic Interventions

The use of ergonomics in job and tool redesign is still in its infancy, largely because an awareness of the science is lacking and not enough cases have been documented showing the effectiveness of these techniques.

However, a few recent demonstration studies have shown reductions in biomechanical stress with ergonomically designed tools, such as the contoured hand grip on pliers for electrical wiring and the specifically shaped knife for poultry processing. Controlled intervention trials are also needed to demonstrate actual reductions in the prevalence of symptoms and injuries.

Initial economic considerations combined with the lack of sufficient substantive evidence for effectiveness have dissuaded many industries from implementing job redesign that might result in reduced injuries and lost work time and ultimately in potential savings.

In contrast, some industries, when faced with staggering workers' compensation costs and rising disability insurance premiums (e.g., those tied to back injuries from manual materials handling), have been motivated to seek out and implement ergonomic solutions. Some have found ergonomic job redesign an effective adjunct to cost-reduction programs. Analyses often demonstrate that ergonomic intervention can reduce musculoskeletal injuries and also contribute to increased productivity. In addition to decreased medical costs, reductions in lost time from injuries and increased worker productivity can be compelling reasons for adopting an ergonomics program. Equally important, ergonomics can form the basis for an improved quality of work life.

c. Design Principles

For some sources of biomechanical stress, implementing an effective ergonomically based recommendation may be difficult. For example, different overlapping sources of biomechanical stress (e.g., vibration, repetition, load, and posture) may contribute in some unknown way to the onset of musculoskeletal disorders. Often no simple, single change can be made, but numerous adjustments may be required to tailor recommendations to the tool, workstation layout, or organization of the task.

2. Worker Training/Good Work Practices

The success of training programs in reducing musculoskeletal injuries has been mixed. Programs in this area range from rudimentary instruction of workers about safety rules and "how to lift," to elaborate programs conducted by Educational Resource Centers (ERCs) for instructing safety and health personnel in the types of neuromuscular disorders associated with repetitive motion.

Studies that evaluate the effects of training in reducing the back injuries associated with lifting have produced conflicting results. One of the most comprehensive and widely reported studies found no evidence that training had any preventive effect. This finding contrasts with the results of a study evaluating training in materials handling for railway workers, which showed annual decreases in the rate of back injury. The training system was developed in cooperation with a rehabilitation clinic. Similarly studies of “work hardening” or physical conditioning programs designed to improve trunk and leg muscle strength for preventing back injuries have largely failed to confirm the long-term efficacy of the programs.

Efforts are under way in some industries to broaden the training beyond the fundamental issues of safe work practices to include the following:

- Recognition programs for increasing worker awareness of the hazards.
- Problem-solving programs designed to provide workers with the information and skills necessary to participate in hazard control activities.

Many of these more comprehensive training programs have been supported jointly by management and worker organizations. The federal government has provided some limited assistance in grants from the Occupational Safety and Health Administration (OSHA) as part of their New Directions program.

Such worker training programs are believed to be effective in reducing job-related injuries, but available data needed to evaluate such programs are limited, particularly with respect to preventing disorders.

Training and education of professional safety and health personnel is provided in part by NIOSH, especially through its funding of ERCs. The impact of this training is also difficult to gauge in terms of directly reducing musculoskeletal injuries and illness. The ERC program, however, and its ergonomic and musculoskeletal components have stimulated an increased awareness among occupational health professionals of the basis for occupational musculoskeletal injuries. ERCs have also served the local communities as resources for information and guidance in implementing workplace interventions for controlling such injuries.

Thus, training programs have traditionally focused on teaching employees specific work practices for safety and hygiene. Although most experts support such training, the preventive utility has been difficult to evaluate. The concepts of training have been extended recently to include elements of recognition and problem solving. Moreover, education aimed at awareness is now recognized as necessary at all levels of management, including staff specialists, such as tool and workplace designers and engineers.

3. Selection/Placement

Employment screening for musculoskeletal injuries has been used to predict the risk of low back disorders. Selection procedures include anthropometric attributes, such as weight and stature, and the use of back radiographs, muscle strength tests, tests of physical fitness, and tests of lumbar mobility.

The success of any screening program requires accurate information on actual job demands as well as precise measurements of worker capacities related to the key job demands. For example, muscular strength is generally considered an appropriate job-related criterion for work involving manual materials handling. However, measuring the capacities of a worker that most closely reflect the key strength requirements of the job is difficult. Moreover, strength measures are sensitive to many psychologic variables, including motivation, expectation, and fatigue tolerance. Studies in which appropriate measurements have been made show a higher incidence of claimed back injuries and back pain in those jobs demanding high exertion in relation to the worker's own maximal isometric strength.

In contrast, the use of anthropometric guidelines for selecting workers has not been justified in studies of manual materials handlers when the outcome was measured in incidence rates for the reduction of low back pain. Although radiologic measurements have been largely discredited as a screening procedure for back problems, they are still widely used. Caution is urged to avoid a potential radiation hazard from overuse. In theory, the assessment of job demands for work output offers a valid alternative for reducing the incidence of musculoskeletal injuries. In practice, this approach is difficult to implement because of the wide variety of demands inherent in the manual jobs of most industries, the range of individual physical capacities, and the lack of criteria for safely matching workers to jobs.

Thus, the ergonomic approach to workplace redesign may be the first choice for controlling musculoskeletal problems, with employee selection and training secondary. Several reasons for this priority exist.

- a. Selection and training require that each new employee be evaluated, instructed, and thereafter monitored to determine changes in capacity and compliance with the training procedures. In contrast, health promotion programs combined with ergonomically sound jobs and tools are relatively permanent, and, once implemented, do not normally require modification for each new employee.
- b. Employee screening and selection techniques discriminate those considered fit for the job from those who are not. Fitness for a job must therefore be based on actual job demands, which are often difficult to assess. Caution must be exercised that selection procedures are specific to the job, and the general criteria of selecting only the strongest or youngest workers must be avoided.
- c. Although training programs are easily implemented and may initially appear less costly than other forms of intervention, they can be more expensive over time because each new employee must be trained and then periodically given a review.

Recommendations for improving our ability to devise effective interventions are provided in the Action Plan.

D. Increasing Awareness and Stimulating Interventions

1. Obstacles to Implementation

The success of any prevention strategy ultimately depends on the potential for implementation. Implementation may be facilitated by increasing both public and professional awareness of the causes and effects of musculoskeletal injuries and by establishing and then conveying an effective rationale for implementing ergonomic or other solutions to these problems. It is difficult, however, to determine the most effective means of getting the information to the public, and how to best use existing communication networks.

2. Need for Effective Communication Models

Effective communication is particularly important when the subject involves changing attitudes and behavior. The targets of such communication are either individual workers or organizations (including unions and management or both). Various means of disseminating occupational health information have been proposed, ranging from contracts with local physicians to in-plant clinics or comprehensive health maintenance organizations with occupational health specialty services. Sponsors could include corporations, unions, private practitioners, foundations for medical care, independent medical organizations, and local and state governments.

3. Dissemination Needs

Several dissemination needs can be identified. One pressing need is the provision of ergonomically trained personnel at regional levels such as state health departments, industrial commissions, or similar entities (ERCs) who could offer technical assistance on musculoskeletal disorders to employers and employees. Because only two or three centers of ergonomics currently exist in the United States, the number of regional centers should be increased to provide outreach service and education to local employers. The number and quality of special ergonomic and musculoskeletal courses in regional universities also need to be increased. The number and quality of specialized courses to help workers and employers identify acute and chronic musculoskeletal risk factors should be expanded and the necessary training provided for them to devise their own prevention strategies.

A best method has not yet been determined for increasing the awareness of the musculoskeletal problems within small businesses. A significant number of businesses in the United States employ 25 or fewer workers. These small businesses rarely provide occupational safety and health services, and employers and workers may not recognize the special musculoskeletal health problems created by biomechanical stress.

More in-depth courses on occupational medicine and specific treatment should be included in medical school curricula. The NIOSH Minerva project in the ERCs should continue to encourage the inclusion of occupational safety and health subjects, such as ergonomics, in the curricula of schools of business.

Finally, user-oriented guides for prevention and control of cumulative trauma should be disseminated to workers identified through previous surveillance as being in high-risk jobs.

Other dissemination issues involve defining the role of computer technology and telecommunication networks. How should this technology be used to make information about hazards and potential ergonomic solutions more

readily available? What type of public service messages would be effective? What role should occupational and professional organizations play in alerting the public to risk factors for osteoarthritis and to the potential preventive measures involving physical fitness?

Several issues and needs have been outlined. A series of recommended actions for dissemination are proposed in the Action Plan as a first step toward addressing these issues and meeting the identified needs.

VI. Action Plan

Progress in preventing musculoskeletal injuries depends on the cooperation and availability of trained health professionals who are knowledgeable about the nature and extent of musculoskeletal problems in the workplace. Moreover, these trained health professionals must be able to educate workers and employers about risk factors and to assist them in implementing effective control procedures for prevention. Thus, priority for action is based on (1) establishing a coordinating body, (2) educating health professionals and scientists, (3) improving surveillance and research information, (4) developing and evaluating effective interventions, and (5) disseminating information to the public. Recommendations to be implemented immediately are followed by those to be implemented in the near future.

A. What Can Be Done Now

1. Coordinating Body

Establish a National Committee for Occupational Musculoskeletal Disorders to lead a national effort for preventing musculoskeletal injuries; the magnitude and nature of the musculoskeletal problem require input from an expert committee. The composition of the committee must be multidisciplinary and representative of industry, labor, academia, professional groups, and government.

- a. The committee would function as an advisory body to assist in coordinating national efforts in research, training, and prevention.
- b. The committee would also promote clinical and scientific consensus related to:
 - Definitions of occupational musculoskeletal injuries
 - Diagnostic criteria for musculoskeletal injuries
 - Uniform surveillance terms and outcome criteria

2. Training/Professional

Train more clinical personnel in the etiology of musculoskeletal disorders and train more design engineers in biomechanics and ergonomics. This could be accomplished at the regional ERCs and at research centers or clinics that are conducting research in the control of musculoskeletal injuries. Any necessary curricula and training standards should be developed by professional societies.

3. Training/Grants

Establish post-doctoral grants and research assistantships to encourage young investigators to seek advanced training in the prevention of musculoskeletal injuries. Such grants would provide opportunities for recently graduated clinicians and scientists to conduct research under the guidance of experienced senior investigators in occupational biomechanics, kinesiology, epidemiology, industrial rheumatology, ergonomics, and related fields.

4. Training/Workers

Promote worker training programs to emphasize musculoskeletal problems and the need for control. Assuming that the risk of musculoskeletal injury is influenced by industrial behavior, the thrust of the programs should be to encourage workers to participate in the redesign of jobs, tools, and workstations.

5. Education/Awareness

Encourage labor and management to explore new ways of informing workers about sources of biomechanical stress in their job and to explore ways of informing workers about available preventive measures that control the trauma. Programs should be conducted to show successful models.

6. Prevention/Education

Recognize that the occupational nurse is often the first-line link between the worker and health professionals in the community. Hence, nurses should be integrated into occupational health programs concerned with musculoskeletal injuries where they can serve as catalysts and coordinators in promoting musculoskeletal health and preventing disease.

7. Education/Science

Promote active interchange of scientific information. The proposed National Committee on Musculoskeletal Diseases, with sponsorship from private and government sources, would develop agendas for symposia and workshops on topics of basic research for evaluating the causes and effects of musculoskeletal injuries and the means for their prevention.

8. Surveillance Functions

Develop innovative musculoskeletal surveillance systems to improve our understanding of the nature, extent, and magnitude of the problem. NIOSH should place special emphasis on conducting longitudinal studies in cooperation with management, labor, and universities.

9. Research Mechanisms

Promote more research on etiology and prevention procedures through the use of grant mechanisms involving initiatives from NIOSH and the National Science Foundation for research on musculoskeletal injuries at the workplace. This may include the need to consider peer review of research grant applications. Consider establishing a list of standing reviewers to respond to

grant applications that involve areas outside the expertise of the existing study section.

10. Research Topics

Focus research priorities on definitive studies for assessing the relation between an injury or disorder and the particular job task. Such research areas could include:

- a. Determining prospectively whether the pattern of musculoskeletal use influences the pattern or the symptoms of the musculoskeletal injury. Determining whether use makes an underlying disease manifest by precipitating symptoms.
- b. Determining which biologic or anthropometric attributes influence the onset and course of acute and chronic musculoskeletal injuries.
- c. Determining the role of behavioral and lifestyle factors, such as work expectations, loss of sleep, unhealthy diets, or lack of adequate physical fitness, as risk factors for musculoskeletal injuries.
- d. Conducting disease studies to determine whether a particular pattern of musculoskeletal use results in a particular pathoanatomic derangement.
- e. Developing and evaluating clinical screening procedures that improve existing methods of worker classification to match workers to jobs that do not exceed the worker's capacity.
- f. Conducting basic research in biomechanics to validate and enhance existing biomechanical models that further an understanding of the underlying etiology of occupational musculoskeletal injuries and their prevention.

11. Prevention/Evaluation

Provide financial and staff assistance through a grant mechanism to state and local health agencies, universities, and community health groups that prepares them to perform workplace evaluations, consisting of the following activities:

- a. Conducting epidemiologic studies to identify workplace traumatogens.
- b. Conducting controlled intervention studies (Phase 3-type) to establish the efficacy of proposed countermeasures and prevention strategies.
- c. Conducting demonstration studies in select, high risk industries.

12. Dissemination

Define an implementation/dissemination model for preventing musculoskeletal injuries that includes the following elements:

- a. Identifying target groups; i.e., workers, employers.

- b. Identifying type of messages; i.e., awareness of problems, information on solutions, where to find assistance, and benefits of prevention procedures.
- c. Identifying the most effective medium for target group.
- d. Developing evaluation procedures for feedback on the effectiveness of dissemination programs.
- e. Developing an overall marketing plan to direct the dissemination of prevention strategies for musculoskeletal injuries.

13. Dissemination/Awareness

Use public service information programs and the media in collaboration with societies that represent health professionals to educate clinicians, industrial leaders, and the worker to the true costs of musculoskeletal injuries, in terms of both economics and human suffering. Provide education on the causes, risk factors, prevention, and treatment of disorders associated with occupational musculoskeletal injuries (e.g., carpal tunnel syndrome, office ergonomics, and the use of video display terminals).

14. Prevention/Implementation

Establish a closer liaison between local health services, community health groups, and industry. This could be accomplished with support from a regional ERC. This liaison could be facilitated by the appointment to regional ERC faculties of local specialists in occupational medicine. Emphasis should be given to reaching small business and industries. Small business should be assisted in establishing an ergonomic network to share information on musculoskeletal problems and potential solutions.

15. Education/Awareness

Publish the results of worksite studies in trade magazines and management publications to reach the level of management decision-makers. Illustrate the effectiveness of using worker participation programs, such as the Ergonomic Task Force, for introducing ergonomic changes that have successfully reduced the incidence of musculoskeletal injuries.

3. Recommendations to be Implemented in the Near Future

1. Training/Education

Seek assistance from the National Research Council's National Academy of Engineers to develop and promote curricula in occupational ergonomics and biomechanics for schools of engineering.

2. Surveillance Function

Establish official communication channels with state and federal agencies that gather data to encourage more active collection and identification of data on musculoskeletal health and injury, reflecting long-term as well as short-term effects. Collaborate with state and local occupational health and safety experts to conduct periodic ergonomic-hazard evaluations suitable for assess-

ing emerging health effects stemming from new computer-based technology (e.g., robots, electronic office operations). Consider small grants to state and local health offices to provide training and staff assistance.

3. Prevention/Specifications

Involve the Institute of Industrial Engineers, industrial hygiene organizations, and equipment manufacturers in the development and testing of specifications for cumulative trauma control through the use of ergonomic tool design.

4. Prevention/Control

Use the proposed National Committee on Musculoskeletal Diseases or a subcommittee to coordinate active participation with OSHA, the Mine Safety and Health Administration, the American Industrial Hygiene Association, and state health and industry departments in formulating ergonomic control guidelines for biomechanical stress associated with musculoskeletal injuries.

5. Education/Dissemination

Establish a national clearinghouse of information on work-related musculoskeletal injuries to monitor industrial and technological developments that pose new or modified risks of such problems.

6. Dissemination/Awareness

Seek active participation with the Office of Disease Prevention and Health Promotion in the Department of Health and Human Services and with local and regional state health agencies to improve public and private awareness of the causes and control of musculoskeletal injuries in the workplace. This could be accomplished by public service announcements on television and radio to describe the occupational hazards that pose risks for the back, legs, and wrists.

7. Consensus Standards

Encourage special-interest groups concerned with the rising costs of musculoskeletal injuries and standard-setting groups, such as the American National Standards Institute, to participate in the development of consensus standards applicable to the engineering control of biomechanical stress.

8. Standards Evaluation

Request the proposed National Committee on Musculoskeletal Diseases to evaluate the benefits of adopting a national ordinance or a generic standard similar to the Swedish ordinance (AFS 1983:6, "Working Postures and Working Environments") for controlling biomechanical hazards to the musculoskeletal system.

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3

A Proposed National Strategy for the Prevention of Occupational Cancers

I. Occupational Cancers: Problems and Goals

This document develops a strategy for the prevention of occupationally induced cancer in workers. An organized and coordinated effort by the various levels of governments and the private sector will be required to implement this national prevention strategy.

Occupationally induced cancer usually occurs decades after the exposures that cause the disease process to begin. To date, observed associations between exposure and occupational cancer usually relate to tumors of a common type, such as lung cancer. However, the appearance of even a single case of a very rare form of cancer, such as angiosarcoma of the liver, may indicate an occupational etiologic factor. Sometimes specific cancers occur in such a high fraction of workers that recognition of an association with their job is inescapable. Cancer of the bone in radium dial painters is a good example. However, if only a modest increase in rate occurs, recognition of the association may be more difficult.

While present public health officials now ponder which occupational agents may be carcinogens and to what degree, it should be remembered that 200 years have passed since it was first recognized that chemical agents found in the workplace can cause occupational cancer. An astute clinician, Sir Percivall Pott, in 1775 first linked cancer of the scrotum among chimney sweeps to their occupational exposure. Like other observers lacking 20th century scientific knowledge and methods, Sir Percivall discovered this association using epidemiologic concepts such as the interactions of *agent*, *environment*, and *host*. No doubt, his confidence was bolstered by his observation of a specific *agent*, the soots and tars, and he probably wondered whether some attribute, such as the young age at which the boys (*hosts*) were exposed to the soots and tars, contributed to their unusual risk, and whether the *environment* in which the small boys worked could be altered to eliminate the continued contact of soots and tars with the scrotal skin. It was not until the 20th century that the particular mechanisms of carcinogenesis and the specific carcinogenic constituents of soot and tar were known. Once specific carcinogenic agents were found, researchers could identify the specific industrial processes producing the exposures and identify the workers at

risk. This provided an opportunity for prevention before clusters of disease occurred among the workers.

Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention, 1979, specifies three health actions for prevention: *health protection*, *health promotion*, and *health services*. These three may be specifically applied in the case of preventing occupational cancers.

Broadly, *health protection* encompasses activities directed at reducing exposure from the offending occupational carcinogen. Redesigning the job to eliminate exposure would be an example of *health protection*. Although *health promotion* has no commonly accepted definition, it connotes an organized program to help employees develop and improve behaviors conducive to good health. For example, cigarette smoking itself is hazardous, but combined with certain carcinogens found in occupational settings, such as asbestos or radon daughters, it can dramatically increase the risk of lung cancer and chronic lung disease.

An educational program aimed at smoking cessation and at warning of the combined hazards of smoking and exposures in the workplace is an example of *health promotion* applied specifically to the prevention of occupational cancers. The third method for intervention, and usually the least satisfactory in the prevention of occupational cancer, is through provision of personal *medical services*. Some cancers, particularly of the skin and bladder, if detected early, are more easily treatable and curable. It is through *health protection*, *health promotion*, and *health services* that the cancer-causing triad of *agent*, *environment*, and *host* can be disrupted and occupational cancer prevented.

II. Scope of the National Problem

Estimates of the fraction of cancers with occupational origin range widely. The limitations inherent in these estimates have been described (Cole and Merletti, "Chemical Agents and Occupational Cancer," *Journal of Environmental Pathology and Toxicology*, III: 399-417, 1980). Even the lowest estimate suggests that 17,000 cancer deaths are attributable each year to workplace exposures. These general estimates do not reflect the specific occupational association in distinct populations of workers exposed to carcinogens. It is not our intention to argue the precise fraction of cancers attributable to occupation or to debate whether this fraction is relatively large or small. Rather, we wish to point out that epidemiologic studies of specific occupational populations, at risk because they have exposure to carcinogens, have demonstrated rates of cancer substantially increased over the expected rate in the general population (Table 1.).

The most recent data collected in 1972 (NIOSH, 1978) indicate that 110,000 workers are potentially exposed to the 21 chemicals (2-acetylaminofluorene, acrylonitrile, 4-aminobiphenyl, inorganic arsenic, asbestos, benzidine, bis-chloromethylether, chloromethyl methyl ether, coke oven emissions, 1,2'-dibromo-3-chloropropane, 3,3'-dichlorobenzidine and its salts, 4-dimethylaminoazobenzene, ethyleneimine, ethylene oxide, alpha-naphthylamine, beta-naphthylamine, 4-nitrodiphenyl, N-nitrosodimethylamine, beta-propiolactone, vinyl chloride, and coal tar) currently regulated as carcinogens by the Occupational Safety and Health Administration (OSHA). If those agents for which OSHA is currently developing standards (e.g., asbestos, benzene, formaldehyde, ethylene oxide, and ethylene dibromide) are added, the number exposed rises to an estimated 1.2 million workers. If one also adds those

agents not presently regulated by OSHA but recommended by the National Institute for Occupational Safety and Health (NIOSH) for control as carcinogens, the total number of workers estimated with potential for exposure increases to approximately 3 to 9 million. No comprehensive estimates exist for the size of the population with past exposure to occupational carcinogens. However, for asbestos alone, an estimated 27.5 million individuals have had past occupational exposure (Nicholson et al., "Occupational Exposure to Asbestos: Population at Risk and Projected Mortality 1980 — 2000," American Journal of Industrial Medicine III: 259-311, 1982). Exposure is neither ubiquitous nor homogeneous but rather is confined to distinct populations with varying degrees of exposure to a diversity of carcinogens.

Table 1. Industrial Agents Associated with Cancer*

Agent	Target Organ	Relative Risk†
Asbestos	Lung, pleura, peritoneum, (mesothelioma)	1.5-12.0 100.0
2-Naphthylamine	Bladder	87.0
Benzidine	Bladder	14.0
Coke oven emissions	Lung, kidney	2.7
Benzene	Blood (leukemia)	2.5
Wood dust	Nasal cavity	500.0
Arsenic	Lung, skin	2.3-8.0
Chromium and chromates	Lung, nasal sinuses	4.0-20.0
Vinyl chloride	Angiosarcoma of the liver	Marked
Bis(chloro-methyl) ether	Lung	100.0

* Abstracted from Schottenfeld and Haas. CA: A Cancer Journal for Clinicians 29: 144-68, (1979).

† Estimated relative risk for workers exposed to agent.

III. Potential for Prevention and Control

This strategy presents a continuum of techniques potentially effective for preventing occupational cancer. This continuum and its relationship to the triad of *agent*, *environment*, and *host* are shown in Table 2.

The strategy proposed for control of occupationally induced cancer consists of techniques implemented within the continuum of prevention. Each action in the continuum will be addressed, indicating what can be done now and what further knowledge is needed to better proceed in the future.

Table 2. The Continuum of Prevention as it Relates to the Triad of Agent, Environment, and Host

Preventive Practice	Agent	Environment	Host
Identification and evaluation of carcinogens	X		
Standard setting	X	X	X
Elimination and substitution	X	X	
Engineering controls		X	
Personal protective devices		X	X
Environmental monitoring	X	X	
Biologic monitoring	X		X
Medical screening			X
Health promotion			X
Therapeutic medical care and rehabilitation			X
Surveillance of disease			X
Surveillance of exposure	X	X	X
Compliance activities	X	X	X
Education of workers and managers		X	X
Use of free market forces for prevention	X	X	X

IV. The Continuum

A. Identification and Evaluation of Carcinogens

1. What Can Be Done Now

- a. Establish a program to coordinate research in epidemiology and toxicology. Although too much coordination can stifle the creativity that leads to progress, improved coordination and communication are needed among all members of the occupational health and safety team (i.e., epidemiologists, toxicologists, industrial hygienists, safety engineers) and among the various professional disciplines. Groups outside government representing both industry and labor should be invited to participate in such coordinating committees. The example of The National Toxicology Program (NTP) within the federal sector illustrates the benefits of coordination. However, NTP does not coordinate or recommend *epidemiologic* research.
- b. Increase support, including funding, for ongoing research to improve methods in epidemiology, toxicology, industrial hygiene, and screening.

2. What Knowledge Do We Need

- a. An inventory of agents that warrant toxicologic and epidemiologic study should be established through an expert committee consisting of the involved government agencies and the nongovernmental sector, including industry management, labor, and academia. Setting priorities and updating the list of agents should be an integral part of the committee's responsibility. Governmental agencies should be required to consider these data in establishing research priorities and setting their regulatory agendas.
- b. Increased understanding is needed of the development, evaluation, and standardization of short-term toxicologic studies, such as cellular and subcellular tests, to delineate their usefulness for decision makers charged with the prevention of occupationally induced cancer. Epidemiologic research often requires substantially more time to complete than experimental studies in animals, while research at a cellular or even subcellular level can be completed more quickly than the other two and may prove less expensive. Unfortunately, results from cellular and subcellular studies are more vulnerable to question because of their uncertain prognostic value for workers.

B. Setting Standards

Several systems exist for setting or recommending occupational standards to prevent exposure to carcinogens. In the workplace, the most familiar is that derived from the Occupational Safety and Health Act, which mandates that NIOSH develop recommendations for OSHA to use in promulgating suitable occupational health and safety standards. Difficulties of this process include the time involved in regulating carcinogens on an agent-by-agent basis; this led OSHA to promulgate a Carcinogen Policy. Standards can also be established for the workplace by other federal agencies, such as the Mine Safety and Health Administration (MSHA) and by state governments, companies, and insurance carriers. Recommendations for standards are also made by voluntary groups, such as the American Conference of Governmental Industrial Hygienists (ACGIH), and the American Industrial Hygiene Association (AIHA).

1. What Can Be Done Now

- a. Clear the backlog of unregulated carcinogens used in general industry by full use of the carcinogen policy that OSHA promulgated in 1981.
- b. Encourage NIOSH, ACGIH, AIHA, NTP, the International Agency for Research on Cancer (IARC), and other groups to continue to identify carcinogens found in the workplace and to promote recognition, voluntary compliance with recommended standards, and the setting of new standards.
- c. Provide technical assistance through NIOSH to states, companies, labor organizations, government agencies, and others in efforts to set standards.
- d. Encourage voluntary organizations to continue disseminating information on carcinogens to all potentially exposed groups.

- e. Encourage efforts to provide information about carcinogenic hazards to workers. One such communication mechanism could be through implementing a broad-based hazard communication standard.

2. What Knowledge Do We Need

Gaps in information used to set priorities for epidemiologic and toxicologic studies should be identified. Ongoing assessments should be conducted of these gaps in information, and the information obtained should be used to influence the selection of toxicologic, epidemiologic, and other research studies needed to support preventive actions.

C. Elimination and Substitution

The most effective way to eliminate exposure to a carcinogen is to eliminate the carcinogen from the workplace. In some cases, the risks of using an agent exceed the benefits, and no valid argument exists for keeping the carcinogen in the workplace. In other instances, interventions less effective than eliminating the agent must be relied on to protect workers.

1. What Can Be Done Now

Increase the efforts of NIOSH, OSHA, MSHA, and other organizations in working with industry, labor, and consumers to obtain information on the toxicity of substitutes that are potentially usable and less hazardous. Lack of toxicity information is sometimes an impediment to eliminating a carcinogen or effectively substituting for carcinogens now in use. Lists of potential carcinogens, substitutes, and replacements should be developed and broadly disseminated.

2. What Knowledge Do We Need

Improved understanding is needed of the potential toxicity and carcinogenicity of materials intended for substitution. When appropriate, recommendations should be made for testing before use.

D. Control Technology

Control technology consists of *engineering controls* that enclose a system or provide ventilation, *administrative controls* that protect against intentional or inadvertent exposure, and *work practices* that minimize worker exposure. Engineering controls are the most preferable, because they are preceived as less likely to fail than personal protective devices or work practices. They also permit the capture and reuse of products that would otherwise be lost to the ambient environment.

1. What Can Be Done Now

- a. Establish a national clearinghouse for information on effective engineering controls and promote the distribution of such information. Government agencies, industry, labor, and academia should work jointly in this effort.
- b. Encourage studies to evaluate the effectiveness of control technologies now used in industry.

2. What Knowledge Do We Need

- a. Examples of effective engineering controls should be identified for specific agents as they are slated for standard setting. A concomitant search for such examples should be made and the information made available through the clearinghouse.
- b. Effective means should be sought to introduce control technology into small businesses that often have no inhouse industrial hygiene services.

E. Personal Protective Devices

When use of a carcinogen in the workplace is essential, and when engineering controls are unavailable or inadequate to ensure protection of the workers, personal protective devices, such as respirators and protective clothing, have a role. The appropriate matching of protective device to hazard is critical because the carcinogens may enter the body by many different routes, including absorption through the skin, inhalation, and ingestion. In addition, personal protective devices are often very specific to the nature of the agent. For example, a glove may be impervious to some solvents but not to others. This requires considerable attention and testing to ensure efficacy. Paradoxically, if a solvent leaks into an impervious glove, the glove may hold the solvent and actually increase rather than minimize absorption. Personal protective devices may even introduce hazards into the workplace, for example, by interfering with vision and dexterity. The effective use of personal protective devices depends on a series of personal and physical assessments of the workers, including their comfort, their perceived value of the device in protecting health, and their physical ability. Personal protective devices must be safe, effective, comfortable, acceptable, and perceived by the worker as valuable if they are to contribute to prevention.

1. What Can Be Done Now

- a. Establish a clearinghouse to disseminate state-of-the-art information on personal protective devices, including information on their failures.
- b. Continue certifying respirators at NIOSH and alert users to possible failures or defects.
- c. Establish medical guidelines to determine which workers are able and which are unable to use personal protective devices effectively.

2. What Knowledge Do We Need

Information based on field testing of personal protective devices is needed to assure their ability to perform in actual work situations; carefully conducted laboratory research on these devices is also important.

F. Environmental Monitoring

Essentially, the role of environmental monitoring is to measure the amount of a carcinogen found in the workplace, to assess the adequacy of engineering controls, and to determine the need for personal protective devices. The complexity of chemical analyses used in environmental monitoring can be a limiting factor in the control of occupational carcinogens.

1. What Can Be Done Now

- a. Encourage NIOSH, OSHA, MSHA, industry, and others to press for the development and dissemination of better and more precise analytic methods for monitoring known and suspected occupational carcinogens.
- b. Support the development of laboratory performance standards through NIOSH and coordinate the testing of laboratories to ensure their accuracy when performing analyses of carcinogens.
- c. Develop and validate strategies for environmental monitoring of carcinogens for field and laboratory use.

2. What Knowledge Do We Need

- a. A plan should be developed to coordinate field validation of analytic methods for carcinogens to ensure that they are as accurate in the field as in the laboratory. NIOSH could provide a lead role in this effort.
- b. A surveillance system should be established to collect, evaluate, and disseminate the results of environmental monitoring.

G. Biologic Monitoring

Two types of biologic monitoring can be done. First, tests are available to measure inherent biologic characteristics of individuals, such as genetic phenotyping for certain enzymes. Second, tests can assess the absorption of specific carcinogens or their metabolites. Little information is available, however, on the value of these tests in preventing disease or on the validity of tests performed in laboratories.

1. What Can Be Done Now

- a. Assess the efficacy of biologic monitoring methods under field conditions, starting with test systems that have been validated in laboratory experiments.
- b. Conduct surveillance of the test results of biologic monitoring for carcinogens or their metabolites in order to identify the worksites where there is exposure to carcinogens.

2. What Knowledge Do We Need

- a. Understanding is needed of the validity of tests that determine enzymatic constitution and of their use in predicting carcinogenic risk. Validation of these tests will determine whether individuals with unusual enzymatic constitutions actually have higher risks of cancer. This will help in developing effective preventive measures and protecting workers against discrimination by use of the tests.
- b. The proficiency of commercial laboratories that perform biologic testing should be ascertained. Currently no laboratory proficiency programs exist for biologic testing, except the biologic testing for some heavy metals.
- c. Research should be initiated into new biologic monitoring methods.

- d. Research is needed to clarify the relationship between monitoring results and disease endpoints.

H. Medical Screening

Cases of occupational cancer continue to occur because of failures in the continuum to prevent them. If these diseases could be detected in the early phase, patients could be treated more successfully and would serve as sentinels that coworkers are at risk.

1. What Can Be Done Now

- a. Establish a series of expert consensus workshops to evaluate the efficacy of medical screening techniques, such as urinary and sputum cytology.
- b. Disseminate state-of-the-art information on medical screening.
- c. Review NIOSH recommendations and OSHA and MSHA regulations on medical screening periodically to ensure that they are consistent with state-of-the-art scientific knowledge.

2. What Knowledge Do We Need

- a. The effectiveness of medical screening techniques for the detection of cancer should be determined.
- b. The effectiveness of subsequent therapy in minimizing and treating occupational cancer should be determined.
- c. More effective methods are needed to identify populations with past exposure to carcinogens so that they can be targeted for effective medical intervention, if available.

I. Health Promotion

Health promotion is generally conceived as an organized program designed to help participants develop and improve their own health maintenance behavior. Only lifestyle factors are considered in this strategy because attempts to help workers reduce their own exposure to occupational hazards are considered health protection. Clearly, cancer can be reduced through health promotion, for example through smoking cessation. Workers exposed to carcinogens may have even greater benefits from smoking cessation than the general population because some carcinogens, such as asbestos, act synergistically with cigarette smoke to increase the worker's risk of cancer more than either agent acting alone. Health promotion should not be considered a substitute for health protection, but an adjunct to the overall prevention strategy.

1. What Can Be Done Now

- a. Include workers and workforces with the other populations targeted for health promotion activities. The American Occupational Medical Association (AOMA), the American Association of Occupational Health Nurses (AAOHN), the American Industrial Hygiene Association (AIHA), and other professional associations could take the lead in this effort.

- b. Support projects that will sensitize the health care establishment to the specialized needs of certain occupational populations.

2. What Knowledge Do We Need

A clear delineation of the interaction between occupational exposures and personal health behaviors is needed to identify those areas where health promotion programs can be most effective and to determine which occupational groups would most benefit.

J. Therapeutic Health Care and Rehabilitation

A decade ago, few clinical experts specialized in the treatment of cancer. Physicians, nurses, or other health care delivery personnel received little training in the prevention of cancer or in occupational medicine. Since then the field of clinical oncology has burgeoned, but the number of hours in the general medical training program devoted to occupational medicine has not expanded comparably. Since many workers are employed in small companies outside the purview of regulation, their medical care is delivered by physicians who are not specially trained in occupational medicine.

Epidemiologic research in the last 25 years has identified numerous populations of workers at increased risk of occupational cancer. Some of these workers could benefit from medical screening, programs for risk reduction, or early treatment. Minorities, who often have the least adequate medical care, should receive prominent attention.

1. What Can Be Done Now

- a. Increase efforts by NIOSH with medical schools, professional associations, and schools of public health to design instructional materials that establish training programs in the prevention of occupational cancer.
- b. Increase collaboration of the American Occupational Medicine Association and other professional organizations, such as the American College of Physicians, with NIOSH in developing educational materials for primary care physicians.
- c. Offer certificates for earned educational credits so that labor and industry can differentiate physicians with some training and understanding of occupational diseases from those without such training.
- d. Establish educational programs and credits of achievement for nurses, in collaboration with the American Association of Occupational Health Nursing, as noted above for physicians.
- e. Increase support to the National Cancer Institute (NCI), which has been instrumental in establishing a network of occupational medicine clinics with strong interests in occupational cancer.
- f. Place experienced occupational health personnel in state and local agencies to encourage interest in the prevention of occupational cancer.

2. What Knowledge Do We Need

- a. Additional information should be gathered from trials of medical interventions. These trials are necessary to determine whether therapy of specific occupational cancers detected early is effective in prolonging life and maintaining its quality.
- b. Understanding should be sought of the most effective ways to provide preventive medical services for small businesses and those not covered by regulation.
- c. The adequacy of early detection, therapy, and risk reduction techniques should be assessed through careful research.
- d. Information is needed to identify populations with past exposures to carcinogens or those known to be at increased risk of cancer. Programs should be initiated for these populations to ensure timely application of diagnostic and therapeutic services.

K. Surveillance of Disease

Occupationally induced cancer is characterized in part by the long interval—often decades—between first exposure and the expression of disease. Thus, surveillance of the disease state will do little to identify worksites with important current exposures. Surveillance of occupational cancer may, however, be effective in detecting new associations between agent, environment, and host. If medical screening and therapeutic interventions prove effective, cases of cancer reported through a surveillance scheme may become sentinel events that identify populations with past exposures who may yet benefit from medical intervention.

1. What Can Be Done Now

- a. Evaluate surveillance schemes to determine which are the most effective in identifying populations that can be helped. This assumes that intervention techniques are available and valuable.
- b. Identify and include sentinel diseases other than cancer in surveillance schemes. Certain acute illnesses, such as chrome dermatitis, may serve as sentinels of important current exposures to known carcinogens.
- c. Place experienced personnel with a knowledge of surveillance in local and state agencies to encourage interest in cancer detection, reporting, and prevention.

2. What Knowledge Do We Need

Better understanding is needed of record-linkage systems and their availability. In the last few years vital statistics data have become available that facilitate the work of epidemiologists (e.g., National Death Index). Other records worth exploring include those collected by the Internal Revenue Service, the Social Security Administration, Workers' Compensation systems, and insurance carriers.

Surveillance of Exposure

Exposure to carcinogens today may lead to cancer 20, 40, or more years hence. Unfortunately, no systematic survey information is now available that gives the extent and level of exposure to suspected human carcinogens or even to the known carcinogens. Such information would be useful for directing societal resources to workplaces with the greatest potential for problems.

1. What Can Be Done Now

Explore data collected in OSHA and MSHA compliance programs to evaluate their usefulness for exposure surveillance. This information may be useful to estimate the extent and level of exposure to regulated and unregulated carcinogens.

2. What Knowledge Do We Need

Systems should be developed to provide national surveillance of occupational exposure to regulated and suspected carcinogens.

M. Compliance Activities

OSHA conducts two major types of inspections: some in response to requests and others targeted to "high-risk" industries. The formula for targeted inspections provides that industries with the highest infraction rates in past years be selected for inspection.

1. What Can Be Done Now

V

- a. Design and evaluate the efficacy of a national system that would target compliance activities to inspect plants using regulated or suspected carcinogens. Because the effects of exposure will not be manifested for 20 to 40 years, inspections are needed to determine whether exposures to carcinogens are occurring.
- b. Determine through an evaluation whether OSHA's current inspection activities are sufficient to ensure coverage of all potentially exposed workers.

N. Education of Workers and Managers

Action to control occupational cancer must come not only from management, professionals, and government, but also—and perhaps primarily—from the interactions of managers and workers, acting in their own self-interests to prevent disease. Education is essential for effective interaction.

1. What Can Be Done Now

- a. Increase the commitment of NIOSH, OSHA, MSHA, NCI, the schools of public health, insurance carriers, and labor to strengthen their educational programs directed at workers, worker representatives, and employers and to include information on the prevention of occupational cancer.

- b. Encourage efforts to provide more information to workers. Implementing a broad hazard communication standard could be an effective part of this program. An evaluation of the effect this communication will have on the behavior of workers should be an integral part of the standard.
- c. Promote worker awareness of occupational cancer hazards and an adherence to the safeguards designed to reduce such risks. This can be done by formulating optimal communication strategies, including public awareness programs.
- d. Establish the value of behavioral approaches and job-design factors in furthering efforts to control cancer in the workplace.

O. Use of Free Market Forces for Prevention

This broad category includes a diverse array of activities unified by the concept that industry and labor operate within an economy as well as a society. Economic forces can be harnessed to help prevent occupational cancer.

1. What Can Be Done Now

Encourage measures to ensure compensation for victims of occupationally induced cancer and allow alternative approaches for reparations. In practice, victims of occupational cancer generally do not receive workers' compensation for several reasons, including the long interval between exposure and disease and the difficulty in establishing a causal relationship between exposure and disease for a particular worker.

2. What Knowledge Do We Need

Understanding is needed to help facilitate collaboration between the occupational health community and the insurance industry in designing economic incentives to maintain a healthful workplace.

V. Summary

More than two centuries have elapsed since an agent found in the workplace was first identified as the cause of cancer in workers. A strategy has been outlined here to better prevent occupationally induced cancer. In the broadest sense, this strategy is an attempt to disrupt the triad of *agent*, *environment*, and *host*. These elements work together to produce occupational cancer, and the different combinations of *agent*, *environment*, and *host* needed to produce the disease depend on the actions of the specific carcinogens. This prevention strategy points the way to a disruption of the triad through *health protection*, *health promotion*, and *health services*. *Health protection* appears to have the most potential for effectively and efficiently preventing occupational cancer, and *health promotion* and *personal medical services* are important adjuncts in this strategy.

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A Proposed National Strategy for the Prevention of Severe Occupational Traumatic Injuries

I. Severe Occupational Traumatic Injuries: Problems and Goals

Severe occupational traumatic injuries include serious, often disabling injuries such as amputations, fractures, severe lacerations, eye losses, acute poisonings, and burns. Worker deaths that are immediate, and without a preceding illness, are often the result of severe trauma incurred on the job.

Control of severe occupational traumatic injuries is not possible without a concerted effort by government, academia, private business, and labor. A control strategy that is national in scope must reflect a full spectrum of activities, not only emphasizing information dissemination and implementation of countermeasures but also including injury surveillance and analytical research. Therefore, the recommendations in this report represent not only what can be practically done today but also what should be done in the future. Embodied in these recommendations is a preliminary national strategy that may evolve as more is learned about the etiology and prevention of traumatic injuries and as more individuals and organizations make contributions to the effort.

II. Scope of the National Problem

Severe occupational traumatic injuries (including injuries associated with work-related motor vehicle accidents) pose a continuing and perhaps the major threat to the health and well-being of American workers. The National Institute for Occupational Safety and Health (NIOSH) estimates that at least 10 million persons suffer traumatic injuries on the job each year. About 30 percent (3 million) of these injuries are severe, and at least 10,000 are fatal. Analysis of potential life lost from various causes indicates that "accidents and adverse effects" are the leading cause of loss of potential productive years of life in this country. Occupational trauma is second only to motor vehicle accidents as a reported cause of unintentional death in the United States.

Occupational injuries, of which severe traumatic injuries constitute one of the important components, resulted in 80 million lost workdays in 1983. That same year, occupational injuries cost the United States an estimated \$33.4 billion in direct costs (e.g., wage losses, insurance administrative costs, and medical costs) and indirect costs (e.g., time lost by other than injured workers, and administrative costs associated with accident investigation and reporting). This figure may grossly underestimate the extent of total costs to industry and to society at large resulting from occupational injuries and cannot begin to describe the immeasurable toll in human suffering.

National Safety Council estimates show declining rates of occupational fatalities and disabling injuries since the early 1970s, partly as a consequence of a growing workforce. However, the actual number of fatalities has declined slowly and the number of disabling injuries has remained essentially unchanged since 1945.

III. Amenability to Intervention

Several techniques and methods are available to prevent and reduce the severity of traumatic injuries. Traditional approaches include removing the hazard, placing barriers between the hazard and the worker (including the use of personal protective equipment), pre-employment screening to prevent assignment of particularly susceptible individuals (e.g., those incapable of performing the tasks or sustaining the stresses imposed by the tasks), job hazard analysis, improved job and tool design, compliance with regulatory and consensus standards, and training the worker to avoid the hazard. Evidence shows that application of traditional trauma prevention methods by knowledgeable professionals in a positive management environment reduces occupational injuries.

A dual approach is proposed to reduce the burden of such job injuries on the workforce, the economy, and the population of the country.

- A. Immediate actions can be taken by interested groups and individuals based on prudent, carefully considered options for trauma prevention programs. These actions involve implementation of already developed and accepted policies and practices to reduce injuries within the context of positive, safety-minded management. Actions that can improve awareness and control of hazards include training; compliance with existing regulatory and consensus standards; better ergonomic design of equipment and jobs; early identification and recognition of emerging hazards; upgraded education of safety and health professionals, engineers, managers, and workers; and targeted, short-term injury control research.
- B. For the long term, a major effort must be made to more thoroughly describe and study occupational injury incidents and to use the most rigorous methods of science available. Although present interventions are valuable in reducing workplace injury, scientific study is necessary because occupational "safety" is a set of control technologies (e.g., engineering, personal protective equipment, and monitoring) and administrative techniques (e.g., training, written policies, safe work practices) that have not been rigorously tested and validated. As an underdeveloped science, occupational trauma control needs research using the scientific methods that have contributed greater knowledge and prevention efforts in related health and injury fields.

One set of scientific methods, known collectively as epidemiology, has received increasing attention among trauma control professionals. Epidemiologic techniques can help those interested in reducing the incidence and severity of occupational trauma to see more clearly the scope of the problem and the complex relationships among the causal factors operating in the working environment.

IV. Epidemiology: Charting the Course

Epidemiology is a discipline applied to the practice of preventive medicine and public health. Use of epidemiology to evaluate the incidence of traumatic occupational injuries has tremendous potential because these injuries, like chronic and infectious diseases, seem to result from the interaction of a susceptible host and one or more etiologic agents within a particular environment. Furthermore, precedents have been established for the successful application of epidemiologic methods to evaluate injury etiology. For example, epidemiology has been used to assess the association of alcohol with automobile fatalities, the occurrence of falls and poisonings in residential buildings, the incidence of occupational and nonoccupational burn injuries, the factors associated with recreational injuries, and the success of various strategies for survival in disasters.

Epidemiology may serve as a common thread associated with the identification, evaluation, and control activities necessary for the prevention of traumatic injuries. Initially, descriptive epidemiology (e.g., surveillance and cross-sectional studies) is needed to *identify* high-risk exposures and factors. This identification will allow for the generation of scientific hypotheses about causation. Next, analytic epidemiology (e.g., cohort and case-comparison studies) can test the validity of these hypotheses. This analysis will allow for the *evaluation* of potential risk factors and exposures and for suggestions of appropriate control strategies. After designating specific control strategies, epidemiologic field and clinical studies can be used to *evaluate* the efficacy of these strategies. Appropriate surveillance activities can then assess progress in the *control* of traumatic injuries based on implementation of specific preventive strategies.

Surveillance appears to be a key epidemiologic component in the prevention of occupational traumatic injury. This component must be viewed as both an initial activity designed to establish baseline information, and as a continuing activity designed to generate dynamic profiles characterizing how the national occupational safety experience is changing, and in some instances, why the change has occurred.

Most workplace accidents occur as a result of the coincidence of separate cause-effect sequences, each influenced by multiple factors or stressors. In formulating actions aimed at controlling severe occupational trauma, consideration must be given to the risk factors associated with the following workplace components: the *task*, the *working environment*, the *machine*, and the *worker*. Each set of risk factors represents an area in need of scientific study in the multidisciplinary effort to mitigate occupational trauma through research.

All too often, however, researchers focus on only one of these aspects without considering the total workplace. Modifications in any component of this complex system must be carefully evaluated with a view toward effects on the total system. Traumatic injury research must be specific and painstaking, yet must reflect a balanced, systems-oriented perspective so that the findings will be adaptable to employers' needs; employers, after all, must manage these complex industrial sys-

tems. Indeed, the importance of management's role in the prevention of occupational traumatic injuries cannot be overemphasized, and providing managers with valid, useful information is a must.

The present discussion follows the order of the workplace components outlined above. It addresses those risk factors of the workplace components for which we now have sufficient information to implement effective intervention strategies and then examines those risk factors for which critical knowledge gaps must still be explored before meaningful intervention can begin.

V. Prevention Components: What We Know and Can Implement Now

Energy release is associated with the interaction of task, environment, machine, and worker. Traumatic injuries may result from employee exposures to unexpected releases of energy in amounts that the human body cannot tolerate. The release of energy that results in harm is usually due to lack of management control or improper management of the working environment.

Programs established to reduce occupational traumatic injuries must be formulated and implemented by management. Management policies, procedures, and supervision dictate how effective injury prevention efforts will be.

Evaluation of effective safety programs has established that the most important component of such programs is management's commitment from the top down. Such programs contain basic elements such as safety policy statements, assignment of safety responsibilities through all levels of management, establishment of safety performance accountability, identification of hazards in the workplace, establishment of control measures (in accordance with regulatory and consensus safety standards), employee involvement in hazard identification and control, safety training for employees, accident investigation policies, and planning for emergencies. Management accepts the responsibility of tying these elements together so that the nucleus of the industrial system (task, environment, machine, worker) can function with the least possible unforeseen interruption.

A. Task-Oriented Strategies: Modifying the Job

Failure to follow established standards for work practice is considered responsible for a large portion of occupational injuries and deaths. Reduced numbers of injuries and deaths can result from the increased use of effective work practices.

Safe work practices exist for many hazardous operations. Control methods exist for all energy sources found in United States workplaces. The extent of occupational injury incidence indicates that employers either are unaware of the hazards inherent in their operations, or the appropriate control strategies, or are unable or unwilling to effectively implement those strategies. This indicates weaknesses in dissemination and employers' safety programs.

Employers can use job hazard analysis as a technique to identify job hazards and appropriate preventive countermeasures. All job tasks should be analyzed individually from the perspective of identifying obvious, anticipated, or foreseeable hazards. Of course, not all hazards are immediately obvious or can be reasonably foreseen. Programs should include timely reassessment or monitoring activities

to detect previously unknown or undetected hazards. Appropriate preventive countermeasures can then be applied to eliminate or reduce risk to the worker from those hazards, including modifications to the task. Job hazard analysis is an important approach because hazards can often be anticipated. This is clearly better than reacting to a hazard after a traumatic event.

Although the effectiveness of known countermeasures has not been determined, increased implementation of appropriate safe work practices and procedures is anticipated to have a major impact on reducing national injury and death rates.

B. Environment-Oriented Strategies: Changing the Work Environment

The working environment includes the physical environment, the psychosocial environment, and the political/economic environment. Of these, the physical environment is the most amenable to immediate action. The impact of broader environmental issues on the incidence of traumatic injuries must be carefully studied.

The influence of factors in the physical environment (e.g., layout and condition of the facility, illumination, temperature, relative humidity, noise, vibration) on the productivity and safe performance of occupational tasks has been studied for more than 50 years. Based on consensus and standard industry practice, guidelines have been developed for the control of these potential physical stressors to minimize direct bodily insult or trauma. Compliance with these guidelines can help to reduce the risk of occupational injury. The principal obstacles to wider application of known controls are inadequate information dissemination and inadequate safety program management. Cost constraints can also inhibit adoption of necessary environmental controls.

Many private sector organizations have developed safety and health prevention programs that have demonstrated trauma reductions and worker health enhancement. Means should be sought through trade associations, the National Safety Council, labor organizations, insurance organizations, and others to influence other companies to incorporate the essential aspects of such effective programs into programs of their own.

C. Machine-Oriented Strategies: The Safe Machine

Machines are assemblages of parts designed to transmit or modify the application of power, force, or motion to perform predetermined functions. Workers use a wide variety of machines to be more productive. The various forms of energy associated with machines, if not adequately controlled, can result in traumatic injuries to workers. Numerous measures known to control this release of energy should be applied in the workplace.

1. Standards

Regulatory and consensus standards now exist to protect workers in various ways from interaction with specific industrial machines. Many of these protective measures propose the placement of barriers between the worker and recognized hazardous energy sources associated with the machinery. These barriers range from guards placed on moving pieces of machinery to protective equipment worn by workers. References to recognized controls can be found in the occupational safety and health standards and appropriate publica-

tions by consensus organizations such as the American National Standards Institute.

2. Manufacturer Safeguards

Manufacturers are continually seeking to build a better "mousetrap." State-of-the-art technology can be geared toward producing a safer and a more functional machine. Employers should take advantage of proven developments when procuring machines. At a minimum, procurement procedures should require that newly purchased machinery meet all appropriate currently recognized regulatory and consensus standards.

D. Human-Oriented Strategies: Managing the Worker

The most complex and the least measurable component of the task/environment/machine/worker model is the worker. To some safety practitioners, a worker is characterized by the behaviors exhibited in the workplace that influence systems output. Many of these practitioners believe that human behavior is totally unpredictable and uncontrollable. To others, a worker is a set of abstracted attributes: occupation, sex, age, part of body injured, etc. Still others see the worker as the sum of the effects produced by the working environment: stress, injury or illness, disability, fatigue, motivation, productivity or nonproductivity, absenteeism, etc. To some, a worker is a set of psychologic and physiologic capabilities and limitations. Perhaps the most successful practitioners in the area of traumatic injury control see the worker as their most valuable resource, to be carefully nurtured and protected.

Of course, human beings are all of these characteristics and more. Thus, a variety of people need to be involved in the study of tasks, working environments, machines, and workers to comprehend the worker as both an entity and a functioning part of larger systems. Individuals with training and experience in behavioral science, ergonomics, biomechanics, biomedical engineering, and related scientific and engineering fields are needed to study the control of occupational traumatic injury and to provide critical knowledge regarding the human components of industrial systems.

1. Training

Training is an integral component of trauma prevention. From the earliest days of childhood, we are taught to look both ways before crossing the street or, more recently, to buckle our seat belts after getting into a car. As a result, some of us do these things automatically. However, most of us are not trained early in life for the vocation we may have as adults. As a consequence, we get a job and learn firsthand about its inherent dangers.

Strong evidence indicates that knowledgeable, well-trained workers can avoid injury while performing hazardous work, and that untrained, uninformed workers can be injured under almost risk-free conditions. NIOSH field investigations of fatalities associated with confined spaces have shown that lack of awareness or recognition of the hazards, by both managers and workers, and lack of training in hazard awareness may be major factors contributing to occupational fatalities. Government agencies, notably the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA), have addressed the need for training

through standards and educational resources. Although these various regulatory agencies require training, the degree and level of training are seldom specified, resulting in extreme differences in the application of training among similar industries or within the same industry. Also, existing regulations may not cover certain high-risk groups at all, and therefore even minimal training in hazard awareness and control is not provided.

A key activity in the development of training programs is identification of training components that combine to produce a successful program. The establishment of a model training program could ensure that a wider population of workers is provided more uniform and basic training in hazard awareness and trauma control. Of course, such models would require tailoring to meet the specific needs of particular industries, worker populations, and facilities.

Employees in such high-risk occupations as punch press operators, crane operators, industrial truck operators, over-the-road truck drivers, agricultural workers, and workers in many occupations who are exposed to the hazards inherent in confined work spaces, trenches, and chemical handling tasks should be primary targets for such training.

2. Hazard Communication

Effective communication through information dissemination, education, and training could have an immediate positive impact on the incidence of work-related injuries and deaths. Certain workplace energy hazards, or intrinsically dangerous operations such as confined space entry and excavations work, might be effectively mitigated by implementing a program comparable to the OSHA hazard communication standard addressing workplace chemicals (29 CFR 1910.1200). Requiring employers to provide workers with information and training on particularly hazardous aspects of their work could substantially reduce traumatic injuries associated with those hazards.

3. Known Interventions

When surveillance, particularly at the organizational level, identifies the high incidence of a type of injury associated with a high risk industry, occupation, or task (e.g., foot injuries in a foundry), known intervention methods (e.g., protective footwear) should be applied. Training and reinforcing the worker to be aware of the high probability of traumatic injuries are important components of an intervention program. By providing the worker with the tools and knowledge to avoid traumatic injuries, intervention strategies serve as effective models toward prevention efforts.

4. Rehabilitation

Rehabilitation services, available through several programs, provide retraining in different occupations for workers suffering permanent disabling injuries at work. Such programs will increase in importance with the decrease in the number of younger workers entering the workforce and the national trend toward an older workforce.

VI. Prevention Components: What Knowledge Do We Need

Because the basic elements of effective safety programs are known, management can operate such programs efficiently and profitably to reduce occupational injuries. However, to progress in this endeavor, management must have access to cost-effective, scientifically proven methods that reduce injuries, and it must have more information to help allocate limited resources for occupational safety programs. Information valuable to management would include:

- Risks presented in measurable terms
- Methods developed to assess workplace hazards and controls
- Criteria to select workers for specific task, environment, machine, and worker interrelationships
- Components of effective safety training programs
- Means of assessing worker stress indicators in relation to safe job performance
- Access to proven safe work practices and procedures

A. Task-Oriented Strategies: Modifying the Job

Scientific validation is needed for the established countermeasures relating to task procedures. In general, established countermeasures represent the best judgment of the trauma control community, but they have not been demonstrated through rigorous scientific studies to be effective. Recommended procedures for specific tasks would certainly be more readily accepted and used if they were demonstrably effective in reducing worker injury and death. In addition, measurement of the effectiveness of a particular countermeasure would be invaluable in demonstrating the cost-effectiveness to employers, managers, and the public in general.

B. Environment-Oriented Strategies: Changing the Work Environment

1. Physical Environment

Although guidelines are available for controlling harmful environmental agents, the influence of these agents on the incidence of occupational traumatic injuries has not been defined. For example, some initial investigations of the potential detrimental effect of such agents on optimal safety performance have been conducted, but much research lies ahead.

2. Psychosocial Environment

A major impediment to traumatic injury control is the notion, prevalent in the general population, that “accidental” injuries are not preventable. In addition, two fundamental components of the national psychology—risk taking behavior and the perception of personal immunity from injury—extend quite naturally into the working environment. The psychosocial environment, as it influences the perception of hazard and risk taking, is amenable to modification through the techniques of advertising, information dissemination, and social interaction. For example, the decline in cigarette smoking in the United

States can be attributed in large part to two closely related factors: 1) the shift from media saturation with “pro-smoking” advertising toward a more balanced media presentation of smoking (with some media legally prohibited from “pro-smoking” advertisements) and 2) the evolution from an absence of clear scientific and clinical evidence to a flood of information propelled by the Surgeon General’s anti-smoking campaign.

The approach of environmental modification, including efforts to influence coverage by the mass media, should be exploited through a serious concerted effort. Messages must be specific, supportable, and persuasive. General themes such as “safety first” or “think safety” have been minimally effective, if at all. Clearly, modifying public perception to the degree that 1) traumatic injuries are no longer regarded as resulting from “chance” occurrences beyond human control, and 2) the large number of injuries and deaths attributed to work-related trauma are no longer morally acceptable, will represent a quantum leap for a national preventive effort.

3. Political/Economic Environment

a. Changing Work Force

The composition of the work force in the United States has changed dramatically over the past 3 decades. Some industrial sectors are growing much faster than others. For example, from 1950 to 1980 the rates of increase in employment ranged from 14 percent in mining, 28 percent in transportation, and 33 percent in manufacturing, to 170 percent in government, 173 percent in finance, and 234 percent in the service sector.

Fundamental shifts in national employment patterns have continued into the 1980s, such as rapidly increasing numbers of women and increasing participation of certain ethnic minority groups in the work force. Other changing patterns are likely to continue, with some estimates suggesting that less than 10 percent of the national work force will be blue-collar workers by the mid-1990s. The changing economic environment characterized by the exportation of blue-collar jobs and polarization of the work force into professional, technical, managerial, and service occupations has not been fully accommodated by a corresponding change in the thrust of safety program application.

Remodernization, associated with increased use of computers and automated or programmable machines (robots), is rapidly expanding. These factors create a unique and dynamic environment that challenges proponents of traumatic injury prevention and control to anticipate change. Development of positive prevention-oriented planning must occur in parallel with industrial change, not follow it.

b. Emerging Technology

We must begin immediately to apply to problems of the future those organizational and technical lessons learned at such a high cost in the past. After all, our failure to consider the potential hazards of the “new” technologies of yesteryear (e.g., mass production, basic chemicals, and iron and steel) allowed an exorbitant toll in unnecessary injuries and deaths through the years, even to this day. Newly emerging technologies such as

genetic engineering, robotics, computers, and space commercialization are prime candidates for study. To address potential emerging problems will require:

- The widest possible application of existing safety technology
- Development of research programs for safety technology at the centers of the emerging technologies
- Specialized surveillance programs keyed to anticipated problem areas

c. New Hazard Control Techniques

Innovation in techniques for the recognition, analysis, and mitigation of hazards and the management of risk is slowly emerging from extensions of econometrics, policy analysis, reliability engineering, and operations research. However, no formal body of information, discipline, or center of excellence now exists to nurture these new approaches to the safety question. Consideration should be given to establishing a center for research into the non-mechanistic arena of safety.

d. Economic Issues

In 1982, \$22.5 billion were paid for workers' compensation insurance coverage or approximately \$275 per worker covered. Yet the National Safety Council estimates that all workers would need to produce additional goods or services with a value of \$330 per worker to offset the cost of worker injuries. This finding may indicate that compensation insurance rates are not high enough to provide a positive incentive for reducing occupational trauma. In addition, the "liability proofing" that compensation coverage conveys to the employer may provide a further disincentive to prevention programs. Nonetheless, the present compensation system for occupational injuries is important to the nation's working men and women and, although perhaps not ideal, it should be maintained and strengthened.

The economic incentives and disincentives associated with workers' compensation are being carefully analyzed by the insurance industry, private economics-oriented research organizations, and governmental components. Analyses have been undertaken to determine the savings that can be realized through emphasis on prevention, but much work is needed in this area. The emergence of the newly created Workers' Compensation Research Institute (WCRI) is evidence of the increasing attention being focused on understanding the complex economic forces that influence occupational traumatic injury and fatality incidence and the efforts to control these outcomes.

Insurance rates are increasing, the work force is maturing as fewer and fewer young people enter the job market, and labor shortages in key occupations can be anticipated. These influences will require a more enlightened approach to management commitments to worker safety. It is encouraging that many employers are beginning to recognize the negative economic impact that traumatic injuries have in lost workdays, high medical costs, loss of productivity, and increases in insurance rates and liability

claims. Programs should be undertaken to identify the true costs of injuries and fatalities and to more clearly show the economic consequences of trauma. For greater impact, these findings should be specific for industry and occupation; and the results should be widely disseminated.

Furthermore, the human element of this issue of occupational trauma insurance has dimensions beyond just compensation insurance. The cost of not only compensation insurance but of disability and product-liability insurance must be considered as well. From the designer's perspective, liability—especially third party liability—appears to be the driving force. This may operate as a negative force by pushing up disability costs for trauma and related compensation. The cost relationships between these competing insurance elements, whether positive or negative, have never been examined from the perspective of occupational trauma. Studies of this should be undertaken and recommendations made for changes as appropriate.

C. Machine-Oriented Strategies: The Safe Machine

Present concepts of safe machines generally involve installation of barriers or enclosures around hazardous machine parts to prevent accidental worker contact. Although these concepts seem to be effective, employees working with or around machines still experience numerous injuries. This finding implies that several potential problems exist with either the barrier concept or the lack of knowledge of other factors contributing to injuries. Moreover, the large body of voluntary consensus standards for machinery should be reevaluated and refined where appropriate, and wider compliance should be promoted. Establishing and including the current technical basis for each standard as part of the guidelines would enhance user understanding and acceptance and would facilitate necessary revision.

Scientific studies must be performed to determine the efficacy of barrier methods and to provide managers with expected rates of injury reduction through application of these methods. Motivational and behavioral elements, such as piece wage rates, should be evaluated with the associated injury problem.

Machines are being designed to operate faster and with greater reliability in quality control of the product. Production systems are becoming more automated with management goals of totally automated production lines, and new technologic uses of energy are being applied within these systems. These design concepts should take into account safe methods of feeding and removing stock materials and the stressors on workers to keep the automated system running. This should lead to development of controls that minimize human (both manager and worker) error and limit the speed and travel of machines within human reaction tolerances.

D. Human-Oriented Strategies: Managing the Worker

1. Age and Traumatic Injuries

America's population is aging. By the year 2040, an estimated 68.4 million people—one American in four—will be over the age of 65. The 18- to 24-year-old work force, which has traditionally evidenced the highest traumatic injury incidence rates, is declining in size. As the work force gets older, age-

related risk factors for traumatic injuries increase. Older workers give up speed for accuracy, are slower to react in quickly changing situations, and have reduced range of motion compared with their younger counterparts. In addition, they may have less tolerance for changing environmental conditions, such as extreme heat or cold. Although older workers are often considered more cautious and even more productive than their younger counterparts, the decreasing influx of young workers may force older workers to remain in high-risk jobs or activities longer. Therefore, larger numbers of injuries to older workers seem likely, not so much because of diminished physical and sensory capabilities, but because of increased exposure.

Given the changing age of the United States work force, employers have already begun to study ways to attract and keep younger workers. Careful planning will be necessary to reduce traumatic injuries with consideration of the risk characteristics of *both* young and older workers.

2. Training

As our economy changes from heavy industry to service, training will become more important, particularly as new and sophisticated equipment and systems are introduced into the workplace to increase productivity.

Training the worker is an art as well as a science. To master their jobs, and, as a result, to reduce their odds of incurring traumatic injuries, workers have basically been trained in four levels of technology: 1) the worker supplies power and control, such as using a box wrench to tighten a nut, 2) the tool supplies power and the worker controls it, such as using a hand-held power screw gun to drive in a screw, 3) both power and information are supplied, but the worker is in control, such as in a paper-making plant, and 4) power, control, and information are supplied in a self-monitoring system, and workers intervene only if something goes wrong, such as in a nuclear power plant or when an autopilot is activated in an airplane.

In many industrial processes technology is rapidly leaving levels one and two and moving toward levels three and four. Computer technology has made this possible at an accelerated rate. Training of workers and retraining of older workers have become issues that will be of greater importance in the future. Research is needed on the ability of workers to control entire systems and to provide quick, controlled, and reliable responses when problems arise.

The mere provision of training does not ensure that a traumatic event will not occur. The adequacy of training, retraining, and post-training policies and practices needs evaluation to determine appropriate prevention strategies for particular groups of workers in selected work settings. The need for retraining could be evaluated by analyzing surveillance data on the components of traumatic events or investigations of near-misses.

3. Behavior

Human behavior and its relationship to safe work activity have received little if any research attention. Why do workers circumvent safety devices? Why do they attempt to rescue a fallen worker in a confined space only to die themselves in the rescue attempt? What outside workplace forces stimulate or mitigate such behavior? Such issues must be addressed in the context of

the current workplace. Practical techniques of positive reinforcement must be improved and applied for safe work practices.

a. Motivational Factors

Changes toward more service activities, the maturing of the work force, and the decline of the 18- to 24-year-old population have already stimulated major corporations to reexamine the factors that motivate workers. Such studies have focused on economic considerations, with workers hired and maintained on the basis of their motivation to produce. Some attention has been devoted to motivational issues, such as studies of different reinforcing strategies, which may be important to the reduction of trauma in the workplace. More such studies should be undertaken.

b. Employee Participation

In the future, reducing traumatic injuries will involve more group participation than it has in the past. Recently, quality circles, formed in the automobile industry to bring workers, unions, and management together to discuss work issues including safety, have proved to be extremely productive. However, the impact of such participative processes on worker safety has not been fully evaluated scientifically.

In automobile plants, workers have been aiding management in a smoother transition from one technology to another as manual materials handling and assembly give way to automated systems, such as robot material handlers and assemblers. Although the change in technology may reduce some traumatic injuries (e.g., amputations from power presses), impact or crushing fatalities may occur with robots. Therefore, management must initiate ways to enlist the interest and cooperation of workers so that the hazards inherent in new technologies can be fully understood more quickly. Appropriate controls can be developed and made available more rapidly if managers draw on the largest possible pool of expertise available, including workers. Safety researchers need to determine what intervention and prevention programs will be most effective in reducing and eliminating traumatic injuries in computer-mediated work processes.

c. Use and Abuse of Substances

The use and abuse of substances as a factor in highway trauma is well documented. Although the role of alcohol or drug abuse in the occupational setting is less well understood, use of these substances has been linked to such disasters as train derailments. Alcohol, controlled substances, physician-prescribed and self-prescribed medications are known to be used in the workplace, but the magnitude of the problem is largely unknown. Use of a single substance alone (e.g., alcohol) may result in trauma, or personal-use substances may combine with chemicals in the workplace (e.g., inhaled chlorinated hydrocarbons) to produce additive or synergistic effects that contribute to trauma-producing conditions. For example, the pharmacologic effect of a prescribed medication may be altered by a substance present in the working environment. If the effect is increased, it may manifest in an overdose; if the effect is decreased, it may deprive a worker of the needed benefits of medication. Either could contribute to a traumatic injury at or after work. Consistent with its mandate to conduct

research, make recommendations, and train professionals regarding workplace hazards, NIOSH should continue to help those agencies that have specific responsibility for personal behavior and substance abuse by supplying them with technical information and by increasing their sensitivity to worker attitudes and needs.

d. Risk Taking

Risk taking is one of the basic human behavioral factors that made the United States the type of society it is today. We are accustomed to risk taking and are born and raised with the belief that it is the heart of the free enterprise system. Such a philosophy has permeated our society, lifestyles, and workplace. Risk-taking behavior in the workplace is not only recognized but rewarded, such as through piecework wage rates and time-to-complete incentives in the construction industry. This fundamental aspect should receive additional attention and should be modified where possible when it contributes to occupational trauma.

e. Lifestyle Changes

Major life events (e.g., the death of a spouse) are recognized as important health sentinels, but their impact on the risk of traumatic injury has not been systematically studied. Research should be initiated to evaluate whether major life events can increase the risk of occupational traumatic injury. A growing trend in industry is the availability of employee counselors, particularly in larger, well-established companies. Employee concerns may range from family to finances, work, or career mobility. These companies realize that the mental well-being of workers is important and that employees may need trained counselors to help them through crisis periods. Such a service may have an impact on reducing both intentional trauma such as suicide and homicide, and unintentional trauma such as accidental injury resulting directly from inattention.

4. Rehabilitation

Rehabilitation of severely injured workers, although clearly not a prevention technique per se (in terms of initial traumatic events), is a method of mitigating the severity of traumatic injuries by preventing unnecessarily prolonged disability, loss of income, and ultimately reduced quality of life. In addition, employers' rehabilitation programs can serve as evidence of management's commitment to employee well-being, and can, therefore, lend credibility to other, more prevention-oriented aspects of a trauma control program. Current rehabilitation programs are expensive, and the value of such activities has yet to be fully assessed. Evaluations of rehabilitation programs from national, state, local, private sector, and personal perspectives should be conducted with a view toward enhancing the effectiveness of such programs.

One area requiring further research is the development of objective techniques for diagnosing traumatic injuries to specific body parts, in which neurologic and motor dysfunctions are assessed and the worker is given appropriate treatment. Essential considerations from a management standpoint include allowing sufficient time and ensuring mental, psychologic, and physical conditioning to prepare and integrate the worker's return to the workplace. Management should be aware that a gradual recuperative work

period is needed before a worker can return to his potential. Research is needed on the system approach of industry, worker, health care, rehabilitation, return to work, and work adjustment.

VII. Recommendations

Two types of actions are recommended, immediate and long-term. The first set of recommendations can be implemented immediately based on the current state of knowledge and societal organization. The second set reflects the need to 1) scientifically investigate further the causal mechanisms underlying occupational trauma and the available potential control technologies, 2) reevaluate the structure of our existing national programs for addressing the problem of occupational trauma, and 3) assess economic benefits resulting from effective trauma intervention; i.e., a realistic focus on the savings.

A. What Can Be Done Now

1. Develop models of programs for successful occupational trauma prevention and encourage their implementation through a workplace-specific, self-evaluation approach.

Generic components of successful programs for trauma prevention across a variety of industries have included strong management commitment, stable work force, high level of housekeeping and effective environmental quality, and effective training practices. Most employers who voluntarily seek ways to improve programs, such as adaptation of successful program components, are already committed to employee protection. An effort must be made to influence less committed employers to use available prevention tools.

The self-evaluation approach has proven successful in specific industries where self-evaluation tools were keyed to industry-specific characteristics. Several important concepts are embodied in the recommendation: 1) the need to promote the anticipation of hazards through an analytical process, 2) the need to involve the work force in identifying hazards and developing or discriminating among existing controls to address hazards, and 3) the need to tailor self-evaluation tools to specific industrial settings, as demonstrated in the utilities and communications industries.

Two important areas of consideration need to be emphasized: 1) making such self-evaluation procedures voluntary and exempt from punitive repercussions (when such models have been field-tested and validated, promulgation of standards may be feasible), and 2) focusing on two important groups:

- High-risk industries identified through existing data systems and addressed in a priority-setting basis.
- Specific worker populations that may be neglected in coverage by regulatory or statistical databases and may, on scrutiny, be high hazard groups; e.g., agricultural workers, truck drivers, small business employees, the self-employed.

2. Develop information centers for injury prevention technology.

Information about hazard control problems and effective solutions must be

easily accessible to professionals for specific applications. For example, a case study format could be used to compile a source reference available in both "hard copy" and through "electronic access." Selection criteria should also be specified to ensure appropriate quality and technical validity.

In addition, existing information centers need to be broadened to include specific trauma-related data from epidemiologic studies, injury investigations, surveillance and other sources, such as anthropometric, biomechanical, forensic, and physiologic databases.

3. Promote the maximum use of machine guarding technology.

Maximum resources should be used to provide worker protection for all new or rebuilt single-purpose machines and power-transmission devices. All appropriate enforcement agencies are encouraged to use their resources and authority to ensure that appropriate safeguards are installed and used. Another approach would call for model purchase agreements including supplier certification of the presence of current state-of-the-art technology and use restrictions. Special emphasis should be given to mechanical power presses and point-of-operation guards. Whenever possible, guards should be an integral, non-removable part of the machine design to avoid confusion among users about the adequacy of the safeguards. Regulations or recommendations should be made only after clearly demonstrating that specific machines present a hazard, that state-of-the-art technology is available to provide adequate worker protection, and that safeguards will be compatible with the operations and maintenance of the machines and not introduce new worker hazards. Additional efforts should be directed toward producing engineering guides for safe use of multi-purpose machines and machine controls ensuring that warning signs are posted on or near all machines known to present traumatic injury hazards to workers.

4. Integrate the knowledge of traumatic injury control into educational curricula.

A national program should be developed and implemented to draw the attention of educational institutions, professional societies, accreditation bodies, state and local agencies, and others to the need for education and training to control acute trauma and disabling injuries. This program would promote course work in acute trauma prevention in the nation's educational institutions, including schools, colleges, and universities of vocational technology, education, business, engineering, architecture, public health, and medicine. Model program material would be developed for various educational levels ranging from high school to graduate school. Educational materials should be directed through accreditation programs, professional societies, and higher education administrators. Model curricula should include hazard communication, product liability, and control technology information. Other governmental and private programs should be encouraged to participate in the effort.

5. Develop a trauma control training model for specialists, managers, supervisors, and workers.

A model training program for use by all firms in meeting the minimum training requirements specified by regulatory agencies (MSHA and OSHA)

should address the basic elements of the hazard control process—recognition, evaluation, and control. The model should include the following elements:

- Techniques for hazard identification, evaluation, and control
- Methods for ranking hazards according to potential destructive consequences
- Guidelines for selecting training methods
- Materials to be included in presentation
- Methods for evaluating effectiveness of training
- Guidelines for post-training management actions and retraining

Particular concern should be given to worker motivational and behavioral changes and to ultimate distribution of completed programs. The training model should be adapted to the needs of trauma control specialists, managers, supervisors, and workers.

6. Expand occupational trauma research.

Efforts are essential to stimulate the traditional research communities in engineering, universities, and public health to address hazard identification, accident causation, and effective intervention/hazard control with specific funding, such as national grant programs for occupational injury prevention research. The need for interdisciplinary research initiatives in the area of traumatic injury research should be emphasized.

7. Re-evaluate existing occupational consensus standards and codes.

Existing occupational consensus standards and codes must be re-evaluated with a view toward establishing a technical basis for each and, based thereon, appropriate revisions should be pursued. Many occupational standards, regulations, and engineering practices are based on consensus standards or codes and rarely reflect the technical rationale that supports the recommended practice. Therefore, the practitioners who must use such standards or codes have no basis of understanding. In addition, because the technical rationale does not exist, such standards or codes are extremely difficult to review as new information emerges.

8. Monitor product liability decisions.

Because outcomes of product liability litigation have a strong influence on product designers and suppliers, “liability proofing” often overshadows the need to design safe devices for use in the workplace. Occupationally related decisions on product liability should be monitored to identify potential increased risk to workers of traumatic injury. Findings should be disseminated to bodies responsible for consensus standards, regulatory agencies, employers, worker organizations, and related research organizations.

B. Longer Term Actions

1. Develop a national surveillance system for traumatic injuries.

Based on the current limitations of existing documentation and reporting systems for traumatic injury and the redundancies in these systems, it would be highly desirable to establish a single surveillance system that satisfies all regulatory, compensatory, litigation, and research requirements (including causative models). Such a system would relieve American employers and employees who are currently burdened with redundant criteria for reporting information that is often not efficiently and effectively collected, analyzed, and disseminated.

This reporting system for mortality and morbidity from injuries should cover all American workers, regardless of their occupation, the number of employees they work with, or the extent of associated disability. A model with optimal data elements in the system should be developed and tested to fulfill all current and anticipated uses of such data.

Data should include information on products (machines, tools, equipment) used in the workplace, such as identification of manufacturer and model; engineering controls used; personal protective equipment used; job title and tasks; worker characteristics, such as training, experience, and shift factors; compliance with standards; and location of accident.

Information should also include sufficient etiologic descriptions of the circumstances associated with injury incidence. All possible sources of information about injury cases should eventually be tapped, including hospital reports, medical examiner reports, and accident investigation reports. The system should also include denominator data of sufficient detail to assess worker risks of injury when combined with numerator data.

Design of the surveillance system should address the issues of confidentiality (e.g., privacy act requirements) and the consideration of whether the accident investigation data collected should be used for punitive action (introduction of information bias). For selected areas of specific interest, the system should allow further collection of specified information through followup of individual cases.

Although development of a single, comprehensive surveillance system that would satisfy a wide range of data requirements for traumatic injuries might be an ideal solution to the limitations and burdens inherent in existing systems, more practical interim efforts are possible. For example, existing systems might be effectively augmented to expand their value for researchers in traumatic injury control. At present, privacy acts have made some data sources largely unavailable to those studying traumatic injuries. Such sources might provide extensive and useful data if the sensitive information can be properly protected. Surveillance systems specific to industrial sectors and that support industry-specific research efforts might also be feasible (see recommendation #3 below). A variation of the comprehensive system outlined above might entail the collection of a small core of data on each severely injured worker, with mechanisms available to access other pertinent files or accomplish more in-depth sampling of particular types of injuries, agents, populations, or other factors.

2. Promote epidemiologic studies of traumatic injuries and prevention countermeasures.

Epidemiologic methods should be used to study traumatic injuries and provide information about their incidence and prevention. Data from the national traumatic injury surveillance system can be used for case series and cross-sectional analyses to provide statistics describing the magnitude and characteristics of specific traumatic injuries. These analyses can also be used to generate hypotheses and set research and resource priorities. Analytic epidemiologic designs (cohort and case-control studies) should provide risk assessment of selected factors associated with injury incidence. Field trials should be conducted to evaluate the efficacy of specific prevention interventions.

These applications of epidemiologic methods will minimize many current gaps in knowledge about traumatic injury incidence. For example, 1) traumatic injury statistics are often cited that are neither valid nor representative; 2) unsubstantiated conclusions are often made about factors (training, worker behavior, experience, supervision) that influence the risk of traumatic injury; 3) the feasibility and success of prevention countermeasures are either never evaluated or are subjectively supported.

3. Create industrial associations within each major industrial division for research on traumatic injuries.

The continuing toll of occupational injuries and illnesses suggests that national programs established to ensure safe and healthful working conditions are not yielding the desired results. At least two primary reasons can be cited for existing programs not producing effective control measures:

- a. Developing controls and validating effectiveness scientifically require extensive resources not currently available.
- b. Personnel working within national programs lack sufficient familiarity with each specific industry to identify the specific problems and the practical solutions that would result in significant reductions of injury and illness.

To help reduce these problems, a study is recommended to evaluate the possibility of organizing Industrial Traumatic Injury Research Associations for each major industrial division, as defined by the Standard Industrial Classification (SIC) Manual. These associations should be private, nonprofit entities, responsible for performing quality research approved by a tripartite research review board, and should not be for regulatory purposes. Management, labor, and state and federal governments should be equally represented in the administration of these associations. The Construction Safety Association of Ontario is an example of such an association.

Alternative means of addressing research to specific groups might include a division along geographic lines. Indeed, some variances in occupational injury experience may be attributed to regional differences (e.g., geographic, climatic, and demographic). For example, the Occupational Health Program in the State of Washington shows not only an innovative approach to funding but also the level of cooperation possible among government, academia, industry, and labor.

Existing national programs could be used to support the promulgation of occupational regulation, the development of scientific methods for research associations, and the generation of research tools that the associations could apply to problems identified in their specific industries or regions.

4. Examine the use and abuse of substances in the workplace.

The influence of substances on a worker's risk of incurring traumatic injury should be examined carefully through both personal use and workplace exposures, alone and in combination. Substances, medications, and chemicals that can increase the risk of traumatic injury should be identified, as should the workplaces where such substances may be encountered. Methods should be developed to screen workers for susceptibility to these substances and to provide warnings to prevent exposures. On-the-job testing of workers for illicit use of controlled substances has received much recent attention and may be appropriate in targeted, high-risk occupations. Although societal and other pressures often influence affected individuals not to seek assistance for substance abuse, employee assistance programs have proved to be exceptionally effective. Substance abuse should be considered a potential contributing factor to occupational trauma, and effective employee assistance programs should be made available nationwide.

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5

A Proposed National Strategy for the Prevention of Occupational Cardiovascular Diseases

I. Occupational Cardiovascular Diseases: Problems and Goals

Cardiovascular diseases, including ischemic heart disease, hypertensive, cerebrovascular, and peripheral vascular diseases, constitute the leading cause of disability and death in the United States. In 1984, cardiovascular diseases accounted for almost a million deaths (986,000), the majority (555,000) from ischemic or coronary heart disease. The total economic costs (direct and indirect) from cardiovascular disease are substantial, amounting to approximately \$102.4 billion in 1983. Since 1972, coronary heart disease has declined by almost 34 percent. This decline is attributed to a decrease in several risk factors for cardiovascular disease in the population and to improved care for patients with cardiovascular diseases. These changes demonstrate the potential effectiveness of preventive programs directed at risk factors for cardiovascular disease.

Although cardiovascular diseases include a variety of diseases associated with different etiologic factors, several are related to common disease processes and common risk factors. Coronary heart disease, hypertension, and related disease entities are included in this prevention strategy because of their high incidence and prevalence in the United States. Other forms of cardiovascular disease, however, (e.g., arrhythmias, cardiomyopathies) are more directly related to specific occupational exposures or conditions. Although these latter conditions are less common, they receive specific emphasis in this strategy because of their more direct relationship to occupational factors and their resultant vulnerability to intervention in the workplace.

II. Risks and the Workplace

Much is already known about the personal risk factors associated with an increased incidence of coronary heart disease. Major alterable contributors to risk of this disease include cigarette smoking, dietary intake (particularly in relationship to levels of blood lipids), and hypertension. Age, gender, and family history are also important, but not alterable. Other factors include excessive alcohol intake, obesity, diabetes, inadequate physical activity, and behavioral pattern. The available evi-

dence indicates that preventive programs directed at alterable risk factors are already effective in reducing the occurrence of cardiovascular disease. Programs directed at cessation of cigarette smoking, management of hypertension, and change in diet appear to be particularly important.

The workplace can have a deleterious effect on cardiovascular health. A review of existing information on the relationship between workplace factors and cardiovascular disease indicates that millions of workers are currently exposed to work-related factors associated with an increased risk of cardiovascular disease. These factors include exposure to chemical and physical agents in the workplace as well as work-related psychosocial factors. Thus, while the workplace contains factors hazardous to cardiovascular health, it also contains opportunities to prevent and control risk factors for cardiovascular disease. Studies have shown that the workplace is an excellent site for reaching workers with prevention and intervention messages and programs, especially those aimed at reducing personal risk factors for cardiovascular disease.

In this strategy for preventing cardiovascular disease in the workplace, we propose where possible and more efficacious to combine the two approaches: preventing work-related risk factors and enhancing the prevention of personal risk factors. Where it is possible to combine these approaches into an integrated strategy, they offer prospects for substantially reducing the present occurrence of cardiovascular disease.

A. Cardiotoxic Exposures in the Workplace

1. Available Information

Occupational exposures to several chemical and physical agents are known to increase the risk of cardiovascular disease or its manifestations. These agents include carbon disulfide, carbon monoxide, halogenated hydrocarbons, nitroglycerin and related compounds, heat stress, and noise. Occupational exposures to these agents are associated with different manifestations of cardiovascular disease, including immediate deaths from exposures to carbon monoxide or heat stress, acute arrhythmias from exposure to halogenated hydrocarbons, and the development of chronic cardiovascular disease from exposure to carbon disulfide. This variation in the manifestation of specific cardiovascular disease is important to recognize both in controlling these problems and in conducting further research.

Other occupational exposures that may increase the risk of cardiovascular disease include cobalt, lead, antimony, and cadmium. A review of Criteria Documents and Occupational Health Guidelines from the National Institute for Occupational Safety and Health (NIOSH) identified 85 substances with possible cardiotoxic effects. A search of the NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) showed 1,466 chemicals with possible cardiovascular effects. Epidemiologic studies have also identified increased risk of cardiovascular disease for a number of occupational groups, such as clerical workers, fire fighters, and bus and truck drivers. This information provides the basis for a more systematic evaluation of both the substances and the occupational groups to better delineate the cardiovascular risks from such exposures.

Because the cardiovascular disease process is complex, appropriate research methodologies must be carefully developed to study the relationship between occupational exposures and cardiovascular disease. In general, results of research on the relationships of work to cardiovascular health have been less definitive than those for research in many other areas of occupational health, partly because conducting studies in this area is difficult: 1) coronary heart disease has a long latency period during which occupational exposures may vary greatly for an individual, 2) in most epidemiologic studies that have examined personal risk factors, historical information on occupational exposures was not collected systematically, 3) most standard occupational mortality studies have failed to obtain information on personal risk factors (e.g., smoking) or to adjust for selection factors among workers (i.e., "healthy worker effect"), and 4) the complexities of the disease process also make ordinary toxicologic studies quite difficult to design and conduct.

2. What Can Be Done Now

a. Health Protection: Reducing the Environmental Risks

Several steps can be taken to reduce the risks of cardiovascular disease among workers exposed to substances known to increase this risk. Such workers can be identified by examining existing environmental surveillance data (National Occupational Exposure Survey, OSHA inspection records, etc.). Specific programs can be designed to reduce exposures to cardiovascular toxins in these settings. Potential prevention programs should address the need for better communication to the exposed workers about the known hazards (including the development of better methods of conducting this communication); better compliance with current exposure criteria; development and installation of better control technology to reduce specific cardiotoxic exposures; development of better environmental control programs, including improved environmental and medical monitoring; development of better protective equipment; and adoption of new or improved standards for specific exposures (e.g., heat stress, methylene chloride) now known to be hazardous. These programs need to provide for ongoing surveillance of both exposures to these substances and the related incidence of cardiovascular disease; they need to identify new industrial exposures to cardiotoxic agents and new control methods.

b. Health Promotion: Enhancing Healthy Behaviors

As a general rule, programs for health promotion and disease prevention—including the reduction of risk factors for cardiovascular disease—should be initiated at the worksite whenever possible or practical. When environmental factors increase the risk of cardiovascular disease, the need and value of these worksite programs becomes even more pronounced. In an ideal situation, both environmental and personal risks would be addressed through appropriate strategies at the workplace. Programs that address environmental risks should include efforts to reduce personal, modifiable risk factors for cardiovascular disease—smoking, elevated blood cholesterol, elevated blood pressure, sedentary lifestyle, and others. This combined approach offers a favorable interactive effect for reducing the occurrence of cardiovascular disease among workers exposed to agents such as carbon disulfide. Encouraging workers to quit smoking is particularly important because smoking contributes not

only to several cardiovascular diseases but to other diseases as well. Preventive efforts aimed at reducing personal risk factors should be brought to the work setting to ensure that involved workers have full and effective access to them.

However, a combined strategy is not always possible and could even result in a negative effect on both. Some situations may dictate that one set of risks be addressed before the other without hampering the effectiveness of either. For example, cardiotoxic hazards may be so severe in a plant that they must be addressed before efforts are implemented for personal risk factors. Alternately, cardiotoxins may be minimal or even nonexistent in a workplace, and thus it would not be feasible or even reasonable to implement anything but a program for control of personal risk factors.

3. What Knowledge Do We Need

As mentioned previously, better medical, epidemiologic, and toxicologic studies are needed of a number of substances and physical agents to determine their effects on the cardiovascular system in various occupational groups. Given the scant attention paid to occupational factors in past studies of cardiovascular disease, these factors should play a large role in new investigations. Development at NIOSH of an epidemiologic group for cardiovascular disease would provide a useful focus and serve to coordinate this work at NIOSH. This group could also coordinate a program with other agencies and outside groups. Several specific studies are readily suggested for this NIOSH group, including defining the conditions under which arrhythmias occur following exposure to fluorinated hydrocarbons and the interaction of this effect with such factors as caffeine intake; determining whether chronic exposure to carbon monoxide causes cardiovascular disease; evaluating possible cardiomyopathy following exposure to cobalt, taking diet and alcohol intake into account; assessing the effects of antimony on the cardiovascular system; better defining the relationship between hypertension and exposure to noise; and examining several large studies on the risk of cardiovascular disease to determine possible effects of occupational risk. Occupational health researchers must be urged to use available, well-established methods to assess personal risk factors.

If the assessment of occupational exposures in large studies of personal risk factors for cardiovascular disease can be improved (i.e., a standard occupational questionnaire), those studies will be very helpful in assessing occupational risk factors. Coordination with the National Heart, Lung, and Blood Institute (particularly their new series of prospective studies) and with other groups devoted to the epidemiology of cardiovascular disease will also be important in this effort.

A parallel effort should be made to improve methods for toxicologic assessment of possible cardiotoxic substances. Short-term tests are needed to screen substances for their effects on the cardiovascular system, and techniques should be developed for delineating mechanisms of toxicity.

Further research is also required in the related areas of developing new monitoring techniques to assess exposures to cardiotoxic agents (e.g., continuous monitoring of fluorocarbon exposures) and assessing the value of the

training, education, and information dissemination that is directed toward lowering the risk of cardiovascular disease in the workplace.

B. Psychosocial Factors

1. Available Information

Several studies have shown an association of work-related psychosocial factors with an increased risk of cardiovascular disease. In reviewing these studies, it is important to note that the associations often apply only to certain manifestations of cardiovascular disease. For example, work requiring extended vigilance with severe penalties for mistakes (e.g., air traffic controlling) is associated with an increased risk of hypertension but not of other manifestations of cardiovascular disease. Work overload (e.g., being employed in two jobs) is associated with an increased risk of developing angina pectoris and myocardial infarctions but not of sudden death or hypertension. Other psychosocial factors that appear to affect some forms of cardiovascular disease include personality type, socioeconomic status, anxiety, sleep disturbances, life changes, and the administrative organization of the workplace.

2. What Can Be Done Now

Many studies of associations between work-related psychosocial factors and cardiovascular disease are difficult to interpret, and not all attempts to replicate the findings have yielded consistent results. This may be explained in part by the use of slightly different methods in studies that measured similar psychosocial factors and by the frequent lack of controls for other risk factors of cardiovascular disease. Thus, although these studies demonstrate the importance of work-related psychosocial factors in the risk of cardiovascular disease, the specific underlying factors that cause this increased risk are difficult to define. Therefore, our strategy calls for further research in this area rather than the application of specific preventive actions at this time.

3. What Knowledge Do We Need

More information is badly needed on the association between work-related psychosocial factors and the development of cardiovascular disease. This research could focus on several factors, such as machine pacing of work, work overload (e.g., holding two jobs), work organization, job-decision latitude, and various aspects of stress at work. The studies should be done carefully and should control for the effects of other cardiovascular risk factors.

Better methods should be developed and applied to assess workplace psychosocial factors. New technologies that may increase job-related stress (particularly computer-mediated work) should be carefully assessed to limit their adverse effects on workers. Research is also needed to determine the effectiveness of programs that are implemented to correct work-related psychosocial factors (e.g., job redesign, relaxation training).

C. Health Promotion: Role of the Workplace

1. Available Information

The prevention strategies outlined here are directed at specific groups that

may be at increased risk from occupational exposures or psychosocial factors encountered in the workplace. Intervention programs directed at personal risk factors are an important aspect of the strategy for dealing with these occupational cardiovascular problems. However, for the many occupational and industrial groups with increased risk *primarily* from personal factors, the prevention of cardiovascular disease related to these personal risk factors is also an important public health goal.

The workplace is a highly attractive site for delivering health promotion and employee-assistance programs because of certain characteristics of many occupational settings and the high prevalence of many personal risk factors for cardiovascular disease. These programs are rapidly becoming widespread in different industries because they offer the hope of effectively reducing both personal and medical care costs. Programs directed at hypertension control, smoking cessation, and problems of alcohol and other substance abuse appear to provide good models with demonstrated effectiveness. Many industries have also introduced programs focused on dietary changes and physical fitness.

Several factors that are important for the success of health promotion programs at the worksite include management and union cooperation, employee involvement in the program, adequate allocation of resources, and control of the program at the local plant level. Attention to ethical issues is also important in the management of these programs. Programs should be voluntary and should maintain the confidentiality of any medical information collected. All data collected on environmental and personal risk factors should be disclosed to the participants. When programs to control personal risk factors are being conducted in the workplace, environmental hazards there should also be appropriately addressed through the usual mechanisms. In some circumstances, control of environmental and personal risk factors may be addressed through an integrated program.

2. What Can Be Done Now

Efforts should be made to increase the availability of health promotion programs in the workplace. This requires the cooperation of industry, labor unions, community and voluntary groups, and the government. These efforts should include the identification of groups at high risk of cardiovascular and other diseases based on exposure in the workplace and personal risk factors. Effective programs for different industrial and occupational groups should be developed to extend these programs to as many people as possible. The programs should focus on smoking cessation, control of hypertension, dietary changes, physical fitness, and employee assistance for alcohol abuse and related problems. Structured followup and evaluations should be included in individual programs. Although most programs will be conducted in the private sector, governmental agencies can play an important role in stimulating the development of effective programs and in evaluating them.

3. What Knowledge Do We Need

Much information is needed to assess the effectiveness of health promotion programs in the workplace, particularly for different occupational groups and different approaches to these groups. The enormous increase in the preva-

lence of these programs does not confirm their effectiveness; popularity is not the same as efficacy.

The use of occupationally oriented health risk appraisals specifically needs evaluation. Successful worksite-intervention programs that have been limited to particular industries should be evaluated for possible broader application, such as identifying differing approaches based on the size of the industry and the nature of the worksite.

III. Summary

Because of the extent of morbidity and mortality from cardiovascular disease in this country, implementation of this prevention strategy is very important. This effort will require the participation of many groups including industry, labor unions, governmental agencies, and voluntary groups (particularly the American Heart Association). Although our knowledge of the relationship between the workplace and cardiovascular disease is incomplete, several steps can be taken now to reduce this risk; moreover, considerable research is needed to better assess the risk. Implementing an integrated strategy that involves both health protection—to control workplace exposures, and health promotion—to control personal factors that increase the risk of cardiovascular disease, could substantially improve the aggregate health of our workforce.

P/SO

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