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Addressing Health and Safety Hazards in Specific Industries: Agriculture, Construction, and Health Care

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An immigrant farmworker, age 20, was asked to place soil around the perimeter of a tarp covering a field that had been fumigated by injecting methyl bromide gas into the soil. The field was to be used to plant strawberries. It was his first day of work and he was eager to prove that he was a good worker. The ambient temperature was 104°F. After about 4 hours of work, he began to feel nauseous and dizzy. A co-worker told him to drink more water and to take a rest, but he continued to work because he was afraid he would not finish the task. After another hour, he was too dizzy to continue working. He was taken to a clinic in town. At the clinic, the physician asked the worker's supervisor some questions and, after looking up the toxicity of methyl bromide, learned that heat would hasten the volatilization of the gas from the soil. Except for a slightly increased heart rate, the worker's physical examination was normal. Blood tests showed slight electrolyte abnormalities. The doctor diagnosed the worker as having either mild methyl bromide poisoning or heat exhaustion. The doctor called the closest major laboratory, several hours away by car, and found that it would take at least 1 week to determine the worker's blood methyl bromide level. He called the regional poison control center, which told him that there was no specific treatment for mild methyl bromide intoxication. He treated the worker for mild heat exhaustion and had the health educator explain to the worker, in Spanish, the need for frequent rest breaks and good hydration when working in extreme heat and about ways of recognizing and preventing pesticide exposure.*

Some industries pose especially complex challenges for health professionals due to the wide variability of exposures and the high mobility of workers. In these industries, where workers are simultaneously exposed to many different hazards and perform a variety of tasks, it can be difficult to determine which hazard or task is responsible for a worker's health problem. Sometimes, as in the above case, multiple exposures may cause the problem, and determining the responsible exposures may be difficult. While knowledge of the health effects of specific hazards is important, health professionals also need to appreciate the complex factors present in

* Although fictitious, this case was derived from the experience of Dr. Rupali Das, director of the Pesticide Illness Surveillance Program at the Occupational Health Branch of the California Department of Public Health.

hazardous work. In this chapter, we describe three hazardous industries—agriculture, construction, and health care—to address some of these complexities.

Agriculture

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Worldwide, more people work in agriculture than in any other industry, with most engaged in labor-intensive, small-scale subsistence farming. In the United States, although agricultural production is dominated by larger and more mechanized production, farm work remains one of the most labor-intensive and lowest paid occupations. The broad occupational category of farmworkers includes both family farmers who work on their own farms, and hired farmworkers. Although this chapter focuses on the approximately 2.5 million hired farmworkers, owners of family farms face many of the same categories and combinations of hazards.

In 2002 in the United States, 84% of hired crop farmworkers were Hispanic and 79% had been born in Mexico.[1] One-third of foreign-born farmworkers are recent immigrants, who have worked in the United States for 2 years or less; many are living apart from their families and experiencing social isolation that creates additional stress. Farmworkers are younger (average age, 31) than the general workforce and most (79%) are men. Most have very low literacy, which can have significant impact on their ability to read warning labels or understand safety instructions. Only 22% of farmworkers can read and write English well, and more than half have less than an eighth-grade education. For the many who come from rural areas of Mexico, where an indigenous language is spoken, Spanish is their second and English may be their third language.

Forty-two percent of farmworkers face additional stress because of their need to migrate for work and live temporarily away from home, often in crowded and inadequate housing. Hired farmworkers, on average, work in agriculture for only about 8 months of the year. Due to low wages and extended periods of unemployment, the annual family income for more than half of all hired farmworkers is less than $15,000. Since 53% are not legally authorized to work in the United States, they may be vulnerable to abuse and are unlikely to report mistreatment.

In 1960, Edward R. Murrow's classic television documentary, *Harvest of Shame*, shocked viewers by depicting the deplorable working conditions of farmworkers in the United States. Nonetheless, little attention was paid to improving their health and safety conditions until relatively recently. In 1991, the U.S. Surgeon General convened a national meeting on the health of agricultural workers, and subsequently the National Institute for Occupational Safety and Health (NIOSH) established a network of research centers to improve health and safety of family farmers and hired farmworkers. In 1995, NIOSH convened a special panel to make recommendations regarding the priority occupational health problems for hired farmworkers.[2] This panel selected nine priority health outcomes as a focus for future research and intervention, which are listed in Table 36-1, along with heat-related illness because of the recent recognition of its continuing importance. Although the pace of research on agricultural workers has accelerated, these priority health outcomes are still relevant today. The most common of these occupational health problems are discussed in more detail in the sections that follow.

MUSCULOSKELETAL CONDITIONS

From strawberry pickers harvesting crops in a sustained stooped posture to citrus pickers carrying heavy sacks up ladders while reaching for the next orange, farm work is associated with a variety of musculoskeletal disorders (MSDs). In addition, because one-fifth of farmworkers are paid based on the quantity of crops harvested (piece rate), in many work settings there are economic incentives for them to maintain a rapid, sustained work pace. About one-half of all agricultural injuries (Fig. 36-1) requiring time away from work are musculoskeletal injuries, such as sprains, strains, and injuries causing low back pain. To prevent such injuries, some research centers are developing innovative, low-cost methods of improving the ergonomic design of farm work, such as a redesigned tool to carry potted plants (Fig. 36-2). (See also Chapter 27.)

Table 36-1. Selected Hazards, Health Effects, and Control Strategies in Agriculture

Health Effect	Hazard	Control Strategy
Musculoskeletal disorders	Prolonged stooping, heavy lifting, repetitive movements of the upper extremities during planting, pruning, and harvesting	Ergonomic reengineering of tools and workplace; decrease of weight of loads; job rotation among repetitive and nonrepetitive tasks
Pesticide-related conditions	Mixing, loading, and applying pesticides; working in fields recently sprayed with pesticides; aerial drift of pesticides from adjacent fields; exposure to pesticides in living quarters	Substitution with less toxic substances; adequate protective equipment; training on prevention of pesticide exposures; administrative restrictions on working in fields where exposure may occur
Traumatic injuries	Work-related incidents with tractors and other farm equipment; motor vehicle crashes during transport to and from fields; lacerations from sharp tools for cutting and pruning	Use of roll-over protection systems in tractors; training and enforcement of safe use of equipment; transportation vehicles equipped with personal restraint systems; safe cutting tools
Respiratory conditions	Airborne exposure to allergic and irritant substances, either naturally occurring in the soil and crops or due to chemical substances	Substitution with less toxic materials; use of respirators, if indicated; administrative controls to remove sensitized workers from exposure
Dermatitis	Skin contact with allergic and irritant substances, either naturally occurring in the soil and crops or in fertilizers and pesticides	Substitution with less toxic materials; use of gloves and sleeves, if indicated; administrative controls to remove sensitized workers from exposure
Infectious diseases	Inadequate sanitation facilities; exposure to tuberculosis, sexually transmitted diseases, and other infectious diseases due to living arrangement of migrant workers	Improved sanitation facilities; improved housing facilities; improved medical care screening and treatment services
Cancer	Exposure to chemical substances in pesticides and other agricultural products; prolonged sun exposure	Substitution with less hazardous substances; protective clothing and sunscreen; administrative controls to limit exposure
Eye conditions	Exposure to dusty conditions; foreign bodies from plant material penetrating the eye	Use of protective eyewear; dust control
Mental disorders	Long working hours; inadequate pay; social isolation from family and friends	Improved working and housing conditions; availability of mental health services
Heat-related illness	Exposure to hot, humid environments	Educating employers and workers on the hazards of working in hot environments, implementing heat-stress management measures

(*Source*: Adapted from Reference #2 on page 761.)

PESTICIDE-RELATED ILLNESS

Pesticide-related illness refers to a broad group of health outcomes, including dermatitis, eye injuries, respiratory diseases, and cancer. Although many research studies have been conducted on the toxicology and health effects of pesticides, few of these studies have been directed at hired farmworkers. There is no system in the United States to accurately record the national incidence or prevalence of pesticide-related illnesses that occur in the farm sector, although several states collaborate with NIOSH to identify pesticide poisoning cases through the Sentinel Event Notification System for Occupational Risks (SENSOR) pesticides program. (In addition, California, which employs about one-third of all farmworkers in the United States, operates its own reporting system for occupational pesticide intoxications.) Data from these states provide useful information on the nature of farmworkers' exposures to pesticides (Table 36-2). Most overexposures do not occur to those who are applying pesticides, but instead to workers who are inadvertently exposed to pesticides while performing routine farm tasks, such as harvesting and weeding. These overexposures commonly occur when pesticides being sprayed on one field drift into the breathing zone of farmworkers in nearby fields or when workers handle crops

Figure 36-1. Agricultural workers, like this apple picker, face numerous safety hazards. (Photograph by Earl Dotter.)

with pesticide residues.[3] Although less than one-third of cases of pesticide poisoning lead to lost time from work, given the economic insecurity of most farmworkers, it is difficult to determine whether this reflects the affected workers' need to continue working or the mild severity of most cases, or both.

TRAUMATIC INJURIES

Agriculture is considered one of the most hazardous industries for occupational injuries and deaths. Agriculture has an annual occupational fatality rate in the United States comparable to the mining industry, with about 28 fatalities per 100,000 workers. In 2007, the fatality rate in agriculture was almost twice the rate in both construction and transportation.[4] About one-half of all agricultural fatalities occur as a result of transportation incidents, primarily related to tractors. The adoption of roll-over protective structures (ROPS) on tractors has helped to prevent some fatalities. (See Fig. 15-8 in Chapter 15.)

The annual nonfatal occupational injury rate for farmworkers is about 5.4 injuries per 100 workers.[4] Because of the lack of mandatory workers' compensation coverage for many agricultural workers and their fear of lost wages,

A B

Figure 36-2. (A) Picking up and carrying large potted plants in this manner increases the risk of low back and upper-extremity injuries. (B) This device, used as an ergonomic intervention for nursery workers, reduces the need to bend in order to pick up potted plants; it also has a handle designed to decrease stress on the upper extremities. (Courtesy of University of California Davis.)

Table 36-2. Characteristics of 3,271 Acute Pesticide Poisoning Cases in the Agricultural Industry in Ten States,* 1998–2005

Characteristics	Number (Percent)
Gender	
Male	2,189 (67)
Female	1,054 (32)
Organ Systems Affected	
Nervous system	1,743 (53)
Eye	1,300 (40)
Gastrointestinal tract	1,300 (40)
Skin	1,077 (33)
Respiratory system	1,074 (33)
Cardiovascular system	211 (6)
Severity	
Low	2,848 (87)
Medium	402 (12)
High	20 (0.6)
Factors That Contributed to Pesticide Exposure	
Off-target drift	1,216 (63)
Early reentry into a field	336 (17)
Pesticide use in conflict with label	319 (17)
Unknown	992 (30)

*California, Arizona, Florida, Louisiana, Michigan, New Mexico, New York, Oregon, Texas, and Washington.

Source: Adapted from Calvert G, Karnik J, Mehler L, et al. Acute pesticide poisoning among agricultural workers in the United States, 1998–2005. American Journal of Industrial Medicine 2008; 51: 883–898.

there is probably significant underreporting of work-related injuries. For example, a study in North Carolina, a state that does not have comprehensive workers' compensation for farmworkers, found that 8% of workers reported an injury at work in the previous 3 years. Of the injured workers who considered medical attention necessary, 41% did not receive it within 24 hours and 24% never received it. The most common reason why workers did not receive medical attention was refusal by their supervisors to allow them to leave work or lack of transportation. Medical expenses were paid by employers for only 38% of these injuries.[5]

DERMATITIS

Dermatitis among agricultural workers has been associated with exposures to *(a)* a variety of chemical agents, including pesticides; *(b)* sensitivity to plant materials, such as poison ivy and poison oak; and *(c)* infectious agents. In 2007, agricultural workers in the United States had the highest reported incidence rate of cases of dermatitis—twice that of manufacturing workers. Dermatitis is one of the major health problems associated with pesticide exposure (Table 36-2). A study at clinics in the Midwest migrant stream found that, for men age 20 to 29, dermatitis was the primary cause of clinic visits and, for men age 30 to 44, dermatitis was second only to hypertension. The rate of dermatitis among these farmworkers was 2.5 times that of the general population.[6]

INFECTIOUS DISEASES

The pandemic of H1N1 influenza that began in 2009 and previous preparations for an avian influenza outbreak focus attention on how farmworkers would fare during a communicable disease outbreak. Whether working with livestock or crops, farmworkers may have more obstacles to overcome than the general population because of their substandard living conditions, suboptimal access to medical care, and language and cultural barriers.

Poultry workers may be exposed to avian influenza virus at work.[7] Livestock workers may be exposed to viruses or other infectious agents through animals' respiratory secretions, blood, intestines, or excrement. (See Box 36-1.) Protective measures include seasonal influenza vaccine, training on risk reduction for animal influenza viruses, personal protective equipment and training on its use, sanitary facilities for hand washing, and surveillance for early detection of influenza in both workers and animals.

NIOSH solicited input from stakeholders on recommendations for pandemic influenza preparedness among farmworkers, which focus mainly on their cultural, social, and economic situation.[8] State and local public health officials, in collaboration with farm owners and agricultural extension agents, should include migrant

Box 36-1. Livestock Workers

There are approximately 600,000 hired workers on livestock operations in the United States. In agriculture, injuries related to interaction with animals are second only to machinery-related injuries. A study based on injuries of employees of dairy farms, cattle/livestock raisers, and cattle dealers in the Colorado workers' compensation system between 1997 and 2006 found that livestock-handling injuries were more frequent, more severe, and more costly than injuries involving other tasks. For dairy farmworkers, 48% of livestock-handling claims involved milking, with 21% involving a worker being kicked while milking. Among cattle/livestock raisers and cattle dealers, the most common contributing factor for an injury was horseback riding.[1] These data can be used to focus future safety interventions on specific tasks or locations on the farm.

Although the number of livestock operations has been decreasing in the past 10 years, the number of animals and the animal-to-worker ratio on each operation have been increasing, especially with widespread introduction of combined animal feeding operations (CAFOs). Noise exposure has been noted as a hazard on CAFOs. In swine facilities with many animals in enclosed and confined spaces, noise levels above 85 dBA are common. In addition to injuries and noise, other occupational health concerns on CAFO farms include air emissions, such as hydrogen sulfide, ammonia, volatile organic compounds, particulate matter, and endotoxins.[2]

Zoonotic infections, or zoonoses, threaten the health of livestock workers. When 15% to 45% of people in a community work in a CAFO, human influenza cases can increase by as much as 86% due to animals, workers, and other community members infecting each other. Influenza viruses with pandemic potential may also result after coinfection of a person with both an avian influenza virus and a human seasonal influenza virus—through generation of a reassortment influenza virus that is capable of human transmission.[3]

One preventive approach has been to provide seasonal influenza vaccine to workers to reduce opportunities for their simultaneous infection with an animal (avian or swine) influenza virus and a human influenza virus. Reduced opportunities for dual infections decrease the chances of reassortment and the eventual emergence of a novel influenza virus with pandemic potential.

Another approach is early identification and culling of poultry infected with avian influenza to prevent larger outbreaks among poultry; however, these measures could also create severe financial setbacks to farm owners and farmworkers. The threat of lost income may deter farmworkers from reporting ill poultry to supervisors and animal health officials, leading to further spread of virus. Federal regulations stipulate that farm owners and growers may be compensated for costs associated with culling of poultry for detection of avian influenza subtypes H5 and H7, although protection of workers' wages is not required.

The Centers for Disease Control and Prevention (CDC) provides guidelines for protecting poultry workers, which address personal protective equipment (PPE) and training on its correct use, sanitation, and recognition of influenza in birds and people in the event of an avian influenza outbreak in poultry.[4] Many of these same guidelines, especially for PPE and sanitation, are applicable to other livestock workers.

Along with the shift to CAFOs in the production of animal products, the workforce may also be changing. There are no national U.S. data on demographic and economic characteristics of livestock workers as the National Agricultural Workers Survey provides for crop farmworkers, but there has been an increase in the proportion of Spanish-speaking livestock workers, especially on larger farms in the northeastern United States. Spanish-speaking workers are also younger and work more hours than English-speaking workers.[5]

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clinics, unions, and other farmworker service organizations trusted by farmworkers in preparedness planning. Planning should consider disseminating emergency warnings and public health messages through multiple media and the cultural tone, educational level, and language of the message. It may include two-way information networks (via telephone or trusted messengers) to reach farmworkers in remote rural areas and camps. Because resources of farmworkers are limited, there needs to be planning for provision of food, essential supplies, and transportation during emergencies. Since many farmworkers may live in communal arrangements, alternative housing may be necessary to prevent spread of infection. Finally, differentiation of public-health and emergency-response activities from those of immigration enforcement will be necessary to promote cooperation of farmworkers.[8]

HEAT-RELATED ILLNESS

Heat-related illness and death in farmworkers has received renewed attention recently after several high-profile, heat-related fatalities. In response, both North Carolina and California have enacted laws to protect farmworkers from heat-related illness. From 1992 to 1996, the annual heat-related death rate for crop workers was 0.39 per 100,000, compared to 0.02 per 100,000 for all U.S. civilian workers. In addition, most deaths occurred in foreign-born farmworkers. Therefore, interventions should be both culturally and linguistically appropriate for both workers and their supervisors. In response to these findings, measures to manage heat stress were recommended to agricultural employers,[9] including the following:

1. Providing training to prevent, recognize, and treat heat illness
2. Implementing a heat-acclimatization program
3. Encouraging proper hydration
4. Establishing work/rest schedules in accordance with climate conditions
5. Ensuring access to shade or cooling areas
6. Monitoring the environment and workers during hot conditions
7. Providing prompt medical attention to those showing signs of heat-related illness (See Chapter 12B.)

CHILD LABOR

Agricultural work is one of the most common forms and the most dangerous form of child labor. In 2006 in the United States, more than 29 million youths under age 20 were potentially exposed to agricultural hazards as farm residents, farmworkers, children of migrant or seasonal workers, and visitors to farms (Fig. 36-3).[10] Although many are paid or unpaid children of family farmers, an increasingly important group of hired farmworkers are self-emancipated minors, who are primarily unauthorized recent immigrants living and working away from their families. These workers are especially vulnerable to injury because of their age, their undocumented legal status, and their social isolation from friends and family. (See Chapter 4.)

Figure 36-3. Toddlers play in the rows of a field of green onions while their parents work. (Photograph by David Bacon.)

In 2006, there were about 22,900 injuries to children on farms in the United States. The primary causes of injury were falls and incidents involving animals and farm vehicles. Between 1995 and 2002, there were more than 900 farm deaths in children under age 20, of which 13% were work-related. The most common causes of deaths were machinery incidents (23%), motor vehicles (19%), and drowning (16%).[10]

U.S. child labor laws, which regulate working conditions for minors, have many dual standards that provide lesser protection for children employed in agriculture than children employed in other industries:

- The minimum permissible work age is 14 in agriculture and 16 in other industries.
- Children age 12 or 13 may work in agriculture with the consent of their parents.
- Work tasks that have been designated as hazardous by the federal government can be performed at age 16 in agriculture, but not until age 18 in other industries.

In 1996, a national coalition of organizations issued a National Action Plan entitled "Children and Agriculture: Opportunities for Safety and Health,"[11] which led to special congressional funding to improve research and prevention of child agricultural injuries. One of the major accomplishments of this initiative has been the creation of the *North American Guidelines for Children's Agricultural Tasks*, which, in the absence of laws to restrict hazardous work tasks for youth, created voluntary guidelines to assist adults in assigning age-appropriate tasks to children age 7 to 16. These guidelines primarily focus on educating family farmers and influencing their decisions about which farm tasks their children can safely perform.[12]

FEDERAL REGULATIONS AND HEALTH SERVICE PROGRAMS FOR FARMWORKERS

Historically, federal occupational health laws have been less protective of agricultural workers than other industrial workers. Many Occupational Safety and Health Administration (OSHA) standards, such as the Hazard Communication Standard, explicitly excluded agricultural workers. In addition, OSHA is prohibited from regulating farms with fewer than 11 employees. OSHA regulations targeting agriculture include *(a)* the Field Sanitation Standard, which requires water for drinking and hand washing as well as toilets in the fields; *(b)* the Roll-over Protective Structures (ROPS) for Tractors Used in Agricultural Operations Standard, which requires ROPS in tractors manufactured after 1976; and *(c)* the Migrant and Seasonal Agricultural Worker Protection Act (MSPA), which provides migrant and seasonal farmworkers with protections concerning pay, working conditions, and work-related conditions and requires that temporary labor camps operated by agricultural employers meet state and federal safety and health standards.

Occupational pesticide exposure is the only occupational exposure that is entirely regulated by the Environmental Protection Agency (EPA). In 1992, under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the EPA promulgated the Worker Protection Standard, a federal regulation that governs use of agricultural pesticides in commercial production. Its worker health and safety provisions require mandatory training programs, enforcement of pesticide reentry intervals, and provision of washing facilities for decontamination. The enforcement of this standard, which is implemented by cooperative agreements between the EPA and state agencies, has been criticized as being inadequate, in part because FIFRA limits penalties against employers.

Under the Migrant Health Act of 1962, the federal government provides support to over 120 community-based and state organizations that offer comprehensive primary care services to address the special needs of hired farmworkers. As a result of this program, a network of migrant health clinics has been created, which improves provision of medical care for these workers. However, significant obstacles remain due to cultural, linguistic, and logistical barriers that result in many farmworkers receiving inadequate or no medical care.

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See the Further Reading and Web Sites section at the end of the chapter.

Construction

Laura S. Welch

Construction workers build, repair, renovate, modify, and demolish structures—including houses, office buildings, churches and temples, factories, hospitals, roads, bridges, tunnels, stadiums, docks, and airports. To understand injury and illness risks in construction work, one must understand the numerous tasks performed by workers in numerous construction trades (Table 36-3).

Construction often must be done in extreme heat or cold, at night, and in windy, rainy, snowy, or foggy weather. Intermittent and seasonal work adds to health and safety risks and to the stress of job insecurity. Episodic employment, frequent change of employer, and continuous change in worksite exposures and ambient conditions make it difficult to document workers' jobs and hazardous exposures. For all of these reasons, there are only limited data on the nature and magnitude of hazardous exposures in the construction industry.

In developed countries, construction is consistently ranked among the most dangerous occupations. In 2007, 24% of all fatal on-the-job injuries in the United States occurred in construction, although construction accounted for only 8% of total employment.[1] For nonfatal injuries there were 2.4 lost-work-day cases per 100 full-time-equivalent construction workers—more than twice the average for all industry. Leading causes of injuries with lost workdays among construction workers were contact with

Table 36-3. Construction Occupations and Tasks

Boilermakers	Construct, assemble, maintain, and repair stationary steam boilers and boiler house auxiliaries. Work involves use of hand and power tools, plumb bobs, levels, wedges, dogs, or turnbuckles. Assist in testing assembled vessels. Direct cleaning of boilers and boiler furnaces. Inspect and repair boiler fittings, such as safety valves, regulators, automatic-control mechanisms, water columns, and auxiliary machines
Brick masons	Lay and bind building materials, such as brick, structural tile, concrete block, cinder block, glass block, and terracotta block, with mortar and other substances to construct or repair walls, partitions, arches, sewers, and other structures
Carpenters	Construct, erect, install, or repair structures and fixtures made of wood, such as concrete forms; building frameworks, including partitions, joists, studding, and rafters; wood stairways; window and door frames; and hardwood floors. May also install cabinets, siding, drywall and batt or roll insulation
Carpet installers	Lay and install carpet from rolls or blocks on floors. Install padding and trim flooring materials
Cement masons and concrete finishers	Smooth and finish surfaces of poured concrete, such as floors, walks, sidewalks, roads, or curbs using a variety of hand and power tools. Align forms for sidewalks, curbs, or gutters; patch voids; use saws to cut expansion joints
Construction laborers	Perform tasks involving physical labor at building, highway, and heavy construction projects, tunnel and shaft excavations, and demolition sites. May operate hand and power tools of all types: air hammers, earth tampers, cement mixers, small mechanical hoists, surveying and measuring equipment, and a variety of other equipment and instruments. May clean and prepare sites, dig trenches, set braces to support the sides of excavations, erect scaffolding, clean up rubble and debris, and remove asbestos, lead, and other hazardous waste materials
Drywall and ceiling tile installers	Apply plasterboard or other wallboard to ceilings or interior walls of buildings. Apply or mount acoustical tiles or blocks, strips, or sheets of shock-absorbing materials to ceilings and walls of buildings to reduce or reflect sound. Materials may be of decorative quality. Include lathers who fasten wooden, metal, or rockboard lath to walls, ceilings, or partitions of buildings to provide support base for plaster, fire-proofing, or acoustical material
Electricians	Install, maintain, and repair electrical wiring, equipment, and fixtures. Ensure that work is in accordance with relevant codes. May install or service street lights, intercom systems, or electrical control systems
Insulation workers	Apply insulating materials to pipes or ductwork, or other mechanical systems to help control and maintain temperature. Also line and cover structures with insulating materials. May work with batt, roll, or blown insulation materials
Operating engineers	Operate one or several types of power construction equipment, such as motor graders, bulldozers, scrapers, compressors, pumps, derricks, shovels, tractors, or front-end loaders to excavate, move, and grade earth, erect structures, or pour concrete or other hard surface pavement. May repair and maintain equipment in addition to other duties
Painters	Paint walls, equipment, buildings, bridges, and other structural surfaces, using brushes, rollers, and spray guns. May remove old paint to prepare surface prior to painting. May mix colors or oils to obtain desired color or consistency
Paperhangers	Cover interior walls and ceilings of rooms with decorative wallpaper or fabric, or attach advertising posters on surfaces, such as walls and billboards. Duties include removing old materials from surface to be papered
Plumbers, pipefitters, and steamfitters	Assemble, install, alter, and repair pipelines or pipe systems that carry water, steam, air, or other liquids or gases. May install heating and cooling equipment and mechanical control systems
Plasterers and stucco masons	Apply interior or exterior plaster, cement, stucco, or similar materials. May also set ornamental plaster
Reinforcing iron and rebar workers	Position and secure steel bars or mesh in concrete forms to reinforce concrete. Use a variety of fasteners, rod-bending machines, rod busters, blowtorches, and hand tools
Roofers	Cover roofs of structures with shingles, slate, asphalt, aluminum, wood, and related materials. May spray roofs, sidings, and walls with material to bind, seal, insulate, or soundproof sections of structures

(*Continued*)

Table 36-3. Construction Occupations and Tasks (Continued)

Sheet-metal workers	Fabricate, assemble, install, and repair sheet-metal products and equipment, such as ducts, control boxes, drainpipes, and furnace casings. Work may involve any of the following: setting up and operating fabricating machines to cut, bend, and straighten sheet metal; shaping metal over anvils, blocks, or forms using hammer; operating soldering and welding equipment to join sheet-metal parts; inspecting, assembling, and smoothing seams and joints of burred surfaces. Includes sheet-metal duct installers who install prefabricated sheet-metal ducts used for heating, air conditioning, or other purposes
Stonemasons	Build stone structures, such as piers, walls, and abutments. Lay walks, curbstones, or special types of masonry for vats, tanks, and floors
Structural iron and steel workers	Raise, place, and unite iron or steel girders, columns, and other structural members to form completed structures or structural frameworks. May erect metal storage tanks and assemble prefabricated metal buildings
Terrazzo workers and finishers	Apply a mixture of cement, sand, pigment, or marble chips to floors, stairways, and cabinet fixtures to fashion durable and decorative surfaces
Tile and marble setters	Apply hard tile, marble, and wood tile to walls, floors, ceilings, and roof decks

Source: Bureau of Labor Statistics. Standard occupational classification manual, 1998 revision. Available at: http://stats.bls.gov/soc/socguide.htm.

objects (35%), falls (23%), and overexertion (18%). Leading specific diagnoses were strains and sprains (35%), cuts and lacerations (11%), fractures (11%), and bruises and contusions (7%).[2]

Construction injuries comprise a disproportionate share of the total costs of occupational injuries in all industries in the United States—almost $13 billion annually. Fatal injuries account for 40% of this cost; nonfatal injuries and illnesses (mainly injuries with lost workdays) account for the rest. On average, the death of a construction worker results in losses of $4 million, and a nonfatal injury with lost workdays costs approximately $42,000. These estimates include *(a)* direct costs, such as payments for hospitals, physicians, and medicines; *(b)* indirect costs, such as wage losses, household production losses, and costs of administering workers' compensation; and *(c)* quality-of-life costs—that is, the value attributed to the pain and suffering that victims and their families experience as a result of injuries or illnesses.[2]

Employers in construction spend more on workers' compensation than employers in any other industry. In 2005, of all employer costs in construction, 5% were spent on workers' compensation—more than double the costs for manufacturing employers and almost three times the average cost for employers in all industries. Workers' compensation insurance premiums for some occupations were much higher than this average. For example, the median insurance premium rate for roofing was $30 for each $100 of payroll. Nevertheless, only 46% of all medical expenses for work-related injuries were paid by workers' compensation—and only 27% among injured Hispanic construction workers. The remaining amount was paid by workers and their families or by other public or private sources, subsidizing workers' compensation medical coverage in the construction industry by at least $734 million annually.

Occupational diseases are also an important cause of morbidity in construction workers. Table 36-4 summarizes diseases that are sentinel health events that may occur in construction workers and specific hazardous exposures that can lead to these diseases. These sentinel health events help to focus attention on intervention and prevention measures. These hazardous exposures include air contaminants, such as wood dust, abrasive blasting dust, gypsum and alkaline dusts, silica, asbestos, lead, diesel exhaust, and welding fumes.

LEAD AND OTHER HEAVY METALS

Lead exposure and resultant toxicity are especially important problems in the construction industry. (See Chapters 11, 19, and 20.) Excessive lead exposure is associated with several

Table 36-4. Sentinel Health Events in Construction

Condition	Industry/Process/Occupation	Agent
Asbestosis	Asbestos industries and utilizers	Asbestos
Bronchitis (acute), pneumonitis, and pulmonary edema due to fumes and vapors	Arc welders, boilermakers	Nitrogen oxides Vanadium pentoxide
Chronic or acute renal failure	Plumbers	Inorganic lead
Contact and allergic dermatitis	Cement masons and finishers, carpenters, floor layers	Adhesives and sealants; irritants (such as cutting oils, phenol, solvents, acids, alkalis, detergents); allergens (such as nickel, chromates, formaldehyde, dyes, rubber products)
Extrinsic asthma	Woodworkers, furniture makers	Red cedar (plicatic acid) and other wood dusts
Histoplasmosis	Bridge maintenance workers	*Histoplasma capsulatum*
Inflammatory and toxic neuropathy	Furniture refinishers, degreasing operations	Hexane
Malignant neoplasm of scrotum	Chimney sweeps	Mineral oil, pitch, tar
Malignant neoplasm of nasal cavities	Woodworkers, cabinet and furniture makers, carpenters	Hardwood and softwood dusts Chlorophenols
Malignant neoplasm of trachea, bronchus, and lung	Asbestos industries and utilizers	Asbestos
Malignant neoplasm of nasopharynx	Carpenter, cabinet maker	Chlorophenols
Malignant neoplasm of larynx	Asbestos industries and utilizers	Asbestos
Mesothelioma (malignancy of peritoneum or pleura)	Asbestos industries and utilizers	Asbestos
Noise effects on inner ear	Occupations with exposure to excessive noise	Excessive noise
Raynaud phenomenon (secondary)	Jackhammer operator, riveter	Whole-body or segmental vibration
Sequoiosis	Red cedar mill workers, woodworkers	Redwood sawdust
Silicosis	Sandblasters	Silica
Silicotuberculosis	Sandblasters	Silica + *Mycobacterium tuberculosis*
Toxic encephalitis	Lead paint removal	Lead
Toxic hepatitis	Fumigators	Methyl bromide

Source: Adapted from: Mullan R, Murthy L: Occupational sentinel health events: an up-dated list for physician recognition and public health surveillance. American Journal of Industrial Medicine 1991; 19: 775–799. Reprinted with permission from: Sullivan P, Moon Bank K, Hearl F, Wagner G. Respiratory risk in the construction industry. In: Ringen K, Englund A, Welch LS, et al. (eds.). Health and safety in construction. State of the Art Reviews in Occupational Medicine 1995; 10: 269–284.

construction tasks.[3] Almost 1 million construction workers in the United States are exposed to lead at work. More than 80% of these workers are involved in commercial or residential remodeling. Before 1993, the OSHA lead standard applied only to general industry, not to construction. In 1992, blood lead levels (BLLs) in bridge construction workers ranged from 51 to 160 μg/dL, with 62% of elevated BLLs involving work in a containment structure. High-risk activities associated with lead dust and fumes among bridge and structural steelworkers include abrasive blasting, sanding, burning, cutting, and welding on steel structures coated with lead paint, while working in containment enclosures. In 1993, the OSHA lead standard was revised, incorporating a presumption of exposure during specific high-risk tasks and requiring

specific protections during these tasks—unless air monitoring demonstrates airborne lead exposure at a concentration below the permissible exposure limit. However, it is important to recognize that even the revised OSHA standard may not fully protect construction workers from lead toxicity. The standard requires monitoring every 2 months; but some tasks, such as burning lead-coated steel, can cause a rapid increase in BLL. Thus, more frequent monitoring and a lower threshold for mandated industrial hygiene inspection or medical removal of workers has been recommended in some circumstances. Elevated BLLs are reported by 32 states to a national lead surveillance (Adult Blood Lead Epidemiology and Surveillance, or ABLES) program. In 2003 and 2004, the construction industry accounted for 17% of the workers with BLLs at or above 25 μg/dL, while construction employment accounted for only about 7% of the total U.S. workforce. Among the top five industries with the most reported cases of BLLs above 25 and 40 μg/dL in this period were building finishing; highway, street, and bridge work; and utilities. These minimal estimates indicated significant lead exposure occurring in the construction industry.

Construction workers can be exposed to manganese and chromium during welding; pipefitters, ironworkers, boilermakers, and sheet-metal workers routinely perform welding and related processes such as arc cutting. This work often occurs in tanks, boilers, or other poorly ventilated settings. Fumes generated during welding contain fine particles from the base metal, the electrodes, fluxes, and the filler rods. In the United States, there are an estimated 410,000 full-time welders and more than 1 million intermittent welders who are exposed to welding fumes. The International Agency for Research on Cancer (IARC) has determined that welding fumes cause cancer. Welders of stainless steel have higher rates of lung cancer than workers who weld using other metals.

Manganese, a known neurotoxin, is a component of nearly all types of steel and many welding rods and wires. Excessive exposure to manganese in other industries, such as manganese mining and smelting, causes symptoms and signs closely resembling those of Parkinson disease. Recent studies of welders suggest the level of manganese exposure in welding fumes can also cause these symptoms and signs.

Metal fumes from stainless steel welding contain hexavalent chromium and nickel, both of which cause lung cancer. OSHA estimates almost 200,000 construction workers in the United States are exposed to airborne hexavalent chromium, and that a substantial proportion of these workers are exposed above the OSHA permissible exposure limit.

NOISE

Construction workers generally have excessive noise exposures and high rates of noise-induced hearing loss. (See Chapter 21.) More than 500,000 construction workers are exposed to potentially hazardous levels of noise. The United States has a different standard for regulation of noise exposure in construction than in general industry; in the construction standard, there is no action level above which a hearing conservation program is required and there are no detailed requirements for training or record keeping. Yet construction work is very noisy. For example, operating engineers, on average, are exposed to noise levels greater than 85 dBA for 49% of their work shifts and greater than 90 dBA for 25% of their work shifts. A laborer using a heavy-duty bulldozer is exposed to 91 to 107 dBA (mean, 99 dBA). Exposure in crane cabs ranges from a mean of 81 dBA in insulated cabs to 97 dBA in noninsulated cabs.[4]

There are places that have reduced noise exposure in construction. For example, British Columbia implemented, in 1987, a specific hearing conservation program in construction. Since that time, reported use of hearing protection by workers has increased from 55% to 85%, and the proportion of 50-to-59-year-old construction workers with hearing impairment has decreased from 36% to 25%. This program demonstrates the feasibility and efficacy of a specific hearing conservation program in the construction industry.

MUSCULOSKELETAL DISORDERS

Soft-tissue musculoskeletal injuries make up a high proportion of all work-related injuries in

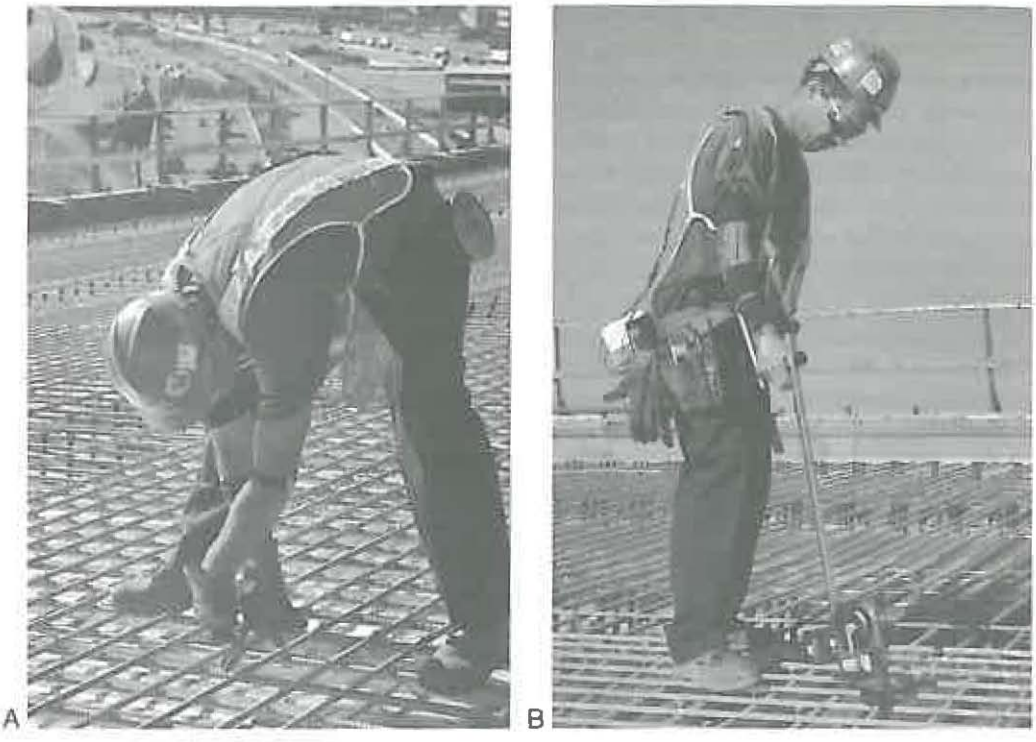

Figure 36-4. (A) Construction workers are at increased risk of upper-extremity and back strain. (B) An ergonomically designed device decreases the upper-extremity and back strain on construction workers who are tieing rebar. (Photographs by Earl Dotter.)

construction (Fig. 36-4).[5] In 2007, there were in the United States an estimated 197,500 injuries and illnesses with lost work days in construction; 35% of these injuries were attributable to strains and sprains and 19% were low back injuries. The rates for these injuries are considerably higher in construction than in all private industry combined.[1,2] Construction workers retire 2 years earlier, on average, than other workers, often because of musculoskeletal conditions, such as arthritis and degenerative disc disease. In a national survey in 1998, 10% of construction workers in the United States reported back pain due to repeated injury at work—twice the rate of all workers. Severe hand discomfort was present in almost 16% of construction workers, compared to 11% of all workers. (See also Chapters 15 and 16.)

Reducing the physical demands on construction workers will require changing the culture of construction, developing new task-specific ergonomic innovations, and promoting participatory ergonomics programs. The construction work environment changes as a project progresses. Both this dynamic nature of the construction process and the project-by-project nature of employment limits employers' incentives to prevent chronic musculoskeletal disorders. Effective interventions to reduce physical demands in construction include decreasing back stress in masons through adjusting work height, eliminating shoulder and neck strain during overhead drilling tasks with a drill support, and various approaches to reduce manual materials handling. Interventions that are more likely to succeed have a perceived relative advantage, are compatible with prevailing norms or practices, can be tried before being fully implemented, and have impacts that are readily observable.[6]

RESPIRATORY DISEASES

Construction workers are exposed to many respiratory hazards, including asbestos, crystalline silica, synthetic vitreous fibers, cadmium, chromates, formaldehyde, resin adhesives, cobalt,

metal fumes, creosote, gasoline, oils, diesel fumes, paint fumes and dusts, pitch, sealers, solvents, wood dusts and wood preservatives, and extremes of temperature.[7] In 2005, the Bureau of Labor Statistics (BLS) reported 1,100 nonfatal work-related respiratory conditions among 7.2 million wage-and-salary construction workers in the private sector in the United States—thought to be a major underestimate. For comparison, the National Center for Health Statistics reported that, in 2000, approximately 20,000 people were hospitalized with asbestosis.

Asbestosis

Asbestos has been recognized as a respiratory hazard for several construction trades. Many construction workers are occupationally exposed to asbestos, especially insulators, plumbers and pipefitters, electricians, and sheet-metal workers. Any construction worker may be at risk for asbestos-induced disease from working near asbestos insulation. Although asbestos is no longer used in new residential or heavy construction, workers may continue to be exposed to previously installed asbestos during maintenance, renovation, addition, or demolition activities.

Silicosis

Occupational exposure to silica can occur among various types of construction workers, including those employed in concrete removal and demolition work, bridge and road construction, tunnel construction, and concrete or granite cutting, sanding, and grinding. Sandblasters are at increased risk from exposure to crystalline silica. Those working nearby on the same construction site may also be at risk from silica-related disease. In the United States, sand containing crystalline silica is still used in abrasive blasting operations for maintenance of structures, preparing surfaces for painting, and forming decorative patterns during installation of building materials; these uses of sand have been banned in many other countries. Silica exposures in the construction industry in the United States continue to exceed recommended limits. Silicosis continues to occur in construction workers worldwide. In addition, silica is a cause of chronic obstructive pulmonary disease (COPD), independent of the presence of radiological evidence of silicosis.

Chronic Obstructive Pulmonary Disease and Asthma

Occupational exposure to the general category of vapors, gases, dusts, and fumes (VGDF) has been have been associated with increased risk of COPD. These exposures, which occur in welding and with use of heavy metals, silica, mineral dust, and adhesives, are common in construction. Chronic obstructive pulmonary disease has been reported among construction workers exposed to asbestos, manmade mineral fibers, and welding fumes; occupations at risk include spray painters, welders, tunnel construction workers, construction painters, and sheet-metal workers. Construction workers can be exposed to allergens, cold, particulates, dusts, fumes, and irritants, all of which can exacerbate asthma.[8] (See also Chapter 18.)

DERMATITIS

Construction workers are exposed to many chemicals that cause irritant or allergic dermatitis (see Chapter 22). Portland cement, which is found in plaster and concrete mixes, is extremely alkaline. Wet plaster also contains slaked lime (calcium hydroxide), which is even more caustic. In addition, Portland cement contains trace amounts of hexavalent chromium, a strong sensitizing agent that causes allergic contact dermatitis in cement workers. Other sensitizing agents include epoxy adhesives, sealants, and chemicals mixed within cement and plaster. Rubber gloves also may cause allergic dermatitis.

For 2005, the BLS reported that skin diseases or disorders accounted for 27% of all occupational illnesses among construction workers. Experts have estimated that the actual number of occupational skin disorders is 10 to 50 times higher than the number BLS reported. One way to prevent allergic contact dermatitis in cement workers is to add ferrous sulfate to hexavalent chromium in cement, a process that forms, when water is added, an insoluble trivalent chromium compound that is not easily absorbed by the skin.

Table 36-5. Epidemiology of Lung Cancer in Construction Workers

Trade	Known Lung Carcinogens
Insulators	Asbestos
Painters and plasterers	Chromium, cadmium, asbestos
Sheet-metal workers	Asbestos, welding fume
Welders	Welding fume, asbestos, hexavalent chromium
Masons	Asbestos, hexavalent chromium, silica
Electricians	Asbestos
Plumbers and pipefitters	Asbestos, welding fume
Roofers	Coal tar, bitumen, polycyclic aromatic hydrocarbons (PAHs)
Carpenters	Wood dust

CANCER

Construction workers are exposed to many carcinogens (Table 36-5). Insulators, painters and plasterers, sheet-metal workers, and other construction workers are at increased risk of lung cancer. Woodworkers, cabinetmakers, furniture makers, and carpenters and joiners have an increased risk of nasal cancer. Workers in many trades have had increased rates of mesothelioma after widespread exposure to asbestos from approximately 1940 to 1980. Given the long latency period for mesothelioma, asbestos-related cases are likely to occur for many years to come. (See Chapter 17.)

REGULATIONS AND HEALTH SERVICES FOR CONSTRUCTION WORKERS

Construction workers are often not covered by the OSHA regulations that cover manufacturing and service sectors. (See Chapter 30.) For example, the standard for noise exposure for the construction industry has no action level above which a hearing conservation program is required, and no detailed requirements for training or record keeping. The rationale for separate OSHA standards for construction is that controls that work in general industry may not work in construction. Therefore, feasibility of a standard must be demonstrated specifically in construction before the standard can be applied to the construction sector. Although this is a reasonable consideration, leaving construction out of a standard until feasibility is demonstrated has led to decades of hazardous exposure for construction workers. Underreporting of injury and illness is prevalent in construction, in part, because the construction industry is comprised mainly of small employers. A legal requirement to report injuries by construction project, which could apply to many small employers, could help to better elucidate and focus more attention on the health and safety problems faced by construction workers.

In the United States, intermittent employment and the high cost of health insurance can leave construction workers and their families without insurance coverage for medical care. In 2005, only 58% of wage-and-salary workers in construction had employment-based health insurance, compared to 75% among all wage-and-salary workers.[2] Because construction is a complex industry, there are proportionately fewer research and prevention activities in construction than in general industry. All of these factors leave the construction industry in great need for improvement in health and safety.

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Health Care

Jane A. Lipscomb

More than 14 million persons (greater than 10% of those employed) in the United States work in health care. About 80% of health care workers are women. The health care sector includes a greater percentage of African Americans and Asians, but a slightly lower percentage of Hispanics, than all industries combined. Some groups within the health care workforce are at increased risk of adverse effects of work-related exposures and demands. For example, registered nurses over the age of 50 are at increased risk of injuries due to the physical demands of patient care. Over the next decade, the number of workers in health care is expected to grow dramatically, with 20% of new jobs in health care. Ironically, health care workers probably confront a greater range of significant workplace hazards than workers in any other sector (Table 36-6), including the following:

- Biologic hazards associated with airborne and bloodborne exposures to infectious agents
- Chemical hazards, especially those found in hospitals, such as waste anesthetic and sterilant gases, hazardous drugs (including antineoplastic medications) and other therapeutic agents, mercury, and industrial-strength disinfectants and cleaning compounds
- Physical hazards, including ionizing and nonionizing radiation
- Safety and ergonomic hazards, which cause a variety of acute injuries and chronic musculoskeletal disorders
- Violence, including physical assaults and threats of assaults
- Psychosocial and organizational factors, including work stress, short staffing, and shift work
- Many health consequences associated with changes in the organization and financing of health care

According to the BLS, in 2007, the occupational injury and illness rate per 100 workers among hospital workers (7.7) was nearly double that of the overall private sector rate (4.2) and higher than rates for workers employed in mining (3.1), manufacturing (5.6), and construction (5.4). Although occupational injury and illness rates have been declining among all industry sectors over the past decade, the decline in the health care sector has been more modest, with the rate ratio for hospital workers compared to all private-industry workers increasing from 1.72 in 2005 to 1.83 in 2007. Workers in nursing homes had an even higher rate of occupational injuries and illnesses—8.8 per 100 full-time workers in 2007.

The health care industry appears to be a decade or more behind other high-risk industries in ensuring safety.[1] There has long been a deep-rooted belief that patient health and safety supersede worker health and safety, and that it is acceptable for health care workers to have less than optimal protection against workplace hazards.[2] For example, infection-control practitioners often promote maximum patient protection while de-emphasizing appropriate measures to prevent worker infections. Both patient and worker hazards arise from the same source—health care practices, products, and materials, and the built environment. Therefore, development of effective approaches to control these hazards requires an integrated approach.[3]

The generation and disposal of biologic, chemical, and radiologic wastes pose risks to communities around health care facilities and beyond, especially if these facilities incinerate their waste on site. The widespread use, and resulting incineration, of plastics containing chlorine compounds, such as polyvinyl chlorine,

Table 36-6. Selected Hazards, Health Effects, and Control Strategies in Health Care

Hazards	Health Effects	Control Strategies
Biological		
Viral (hepatitis B virus, hepatitis C virus)	Acute febrile illness, liver disease, death	Safer needle devices, hepatitis B vaccine
Bacteria (*Mycobacterium tuberculosis*)	Tuberculosis (TB) infection, TB illness, multiple drug resistance, death	Isolation of suspect patients, respirators, ultraviolet light, negative pressure rooms
Natural rubber latex proteins (and rubber chemical additives)	Type I and Type IV immunologic responses; Type I immediate hypersensitivity includes anaphylactic shock	Substitution with low-latex-protein, powderless gloves or nonlatex gloves and supplies
Chemical		
Ethylene oxide	Peripheral neuropathy, cancer, reproductive effects	Substitution, enclosed systems, aeration rooms
Formaldehyde and glutaradehyde	Allergy, nasal cancer Mucous-membrane irritation, sensitization, reproductive effects	Subsititution, local ventilation Substitution, local ventilation
Antineoplastic drugs	Cancer, mutagenicity, reproductive effects	Class 1 ventilation hoods, isolation of patient excreta
Waste anesthetic gases	Hepatotoxicity, neurologic effects, reproductive effects	Scavenging systems, isolation of off-gassing patients
Mercury	Neurologic effects, birth defects	Substitution with electronic thermometers
Physical		
Patient handling	Back pain, injury	Patient handling devices, lifting teams, training
Static postures	Musculoskeletal pain and injury	Rest breaks, exercise, support hose and shoes
Ionizing radiation	Cancer, reproductive effects	Isolation of patients, shielding and maintenance of equipment
Lasers	Eye and skin burns, inhalation of toxic chemical and pathogens, fires	Local exhaust ventilation, equipment maintenance, respirators and face shields
Physical assault	Traumatic injuries, death	Alarm systems, security personnel, training
Psychosocial/Organizational		
Threat of violence, including physical assault	Traumatic injury, death, posttraumatic stress disorder	Training, postassault debriefing
Restructuring	Job strain, exacerbation of musculoskeletal injuries, traumatic injuries, burnout	Acuity-based staffing, employee involvement in restructuring activities; improved safety culture
Additional work stress	Job strain, burnout	Stress prevention and management programs; improved safety culture
Shift work	Gastrointestinal disorders, sleep disorders	Forward, stable, and predictable shift rotation

has the potential to create and release into the atmosphere dioxins, which are highly toxic. Community organizations have successfully advocated for changes, such as phasing out from health care products that contain mercury and bisphenol A (BPA), and reducing incineration of mercury-containing products. In 1998, the American Hospital Association and the EPA signed a memorandum of understanding to prevent release of persistent, bioaccumulative toxic chemicals by hospitals. Now, many hospitals work together with environmental groups to reduce use of chemicals and promote "greener" work practices and environments.

Surveillance of occupational illnesses is even more limited than that of occupational injuries.

In 2005, the incidence of occupational illness among health care workers was 39.9 per 10,000 full-time workers, compared to 26.7 in private industry and 19.6 in the service sector. Nonfatal skin diseases and disorders (7.0 cases per 10,000 workers) and respiratory conditions (5.2) were the most frequently reported illnesses.

MUSCULOSKELETAL DISORDERS

The highest proportion of musculoskeletal disorders (MSDs), which rank second among all work-related injuries, occur among health care workers. Exposures include those involved with lifting, pulling, sliding, turning, and transferring patients; moving equipment; and standing for long periods. Among all categories of workers, hospital and nursing-home workers have the highest number of occupational injuries and illnesses involving lost workdays due to back injuries (Fig. 36-5). (See Chapter 16.)

In 2007, nursing aides, orderlies, and attendants had an MSD rate of 252 cases per 10,000 workers—a rate more than seven times the U.S. average for all occupations. They also reported the most MSD cases involving days away from work (24,340), with a median of 5 days away from work.

Many registered nurses working for at least 1 year have reported neck problems (46%), shoulder problems (35%), and back problems (47%).[4] Almost 80% of nurses experience low back pain during their working lifetime.[5] Nurses reporting highly physically demanding jobs have been five to six times more likely to report a neck, shoulder, or back MSD, as compared with those with less physically demanding jobs. Lifting teams at work, with or without availability of mechanical transfer and lifting devices, have been associated with significantly lower occurrence of back MSDs; nevertheless, many employers still teach body mechanics rather than implementing a comprehensive back injury prevention program. The risk for MSDs is also greater when nurses work shifts longer than 12 hours and on evenings, nights, and weekends.[6]

In the United States, the nursing-home industry spends more than $1 billion annually in workers' compensation premiums, although there is strong evidence that reducing low back load by implementing engineering and administrative controls, such as by safe staffing levels, lifting teams, and use of newer mechanical

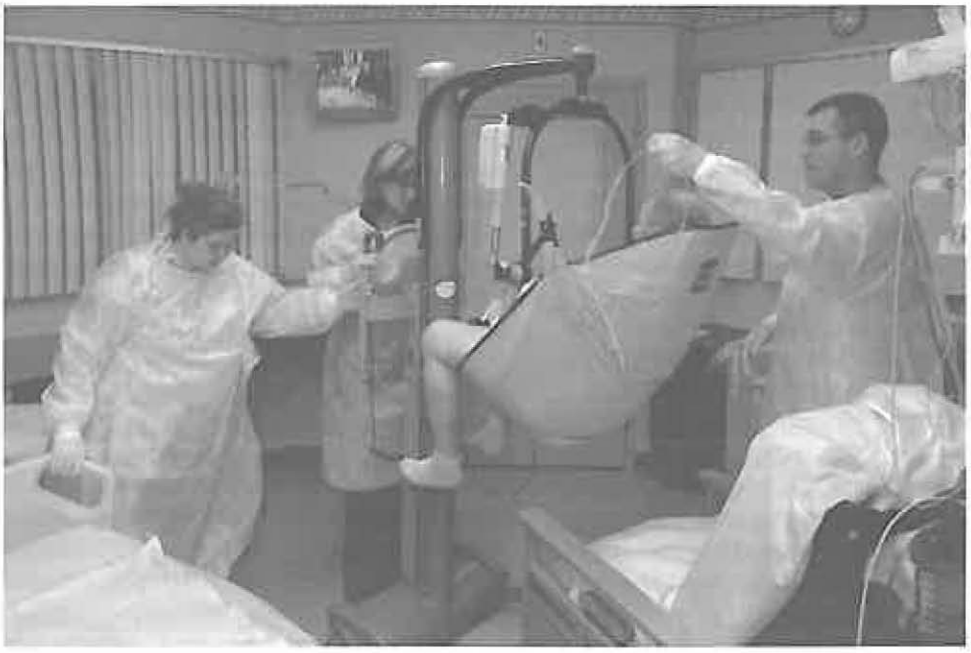

Figure 36-5. Nurses' aides lift a patient by using a mechanical assist device. (Photograph by Earl Dotter.)

patient-handling devices, reduces the risk of injury for both patients and workers. A study that evaluated the effectiveness of a safe resident lifting and movement intervention in nursing homes found that the program reduced the injury rate and workers' compensation costs for injuries due to patient handling, and that the return on investment (ROI) for direct costs of the equipment and training was less than 3 years.[7]

Other health care workers face increased risks for MSDs. For example, laboratory workers are at increased risk for cumulative trauma disorders of the hand and wrist due to repetitive work, such as pipetting. Operating-room workers, who must maintain static postures for long periods of time or hold instruments overhead during long operations, are at increased risks of neck and shoulder pain and injury. Workers who provide health care in patients' homes face risks related to assisting patients who have limited mobility, since few patients have mechanical lifting devices at home and a second person is often not available to assist with patient transfers.

WORKPLACE VIOLENCE

Health care leads other sectors in the incidence of nonfatal workplace assaults. Of all nonfatal assaults against workers resulting in lost work days in the United States, 32% have occurred in the health care sector. In about half of nonfatal assault injuries, patients are the perpetrators. In 2005, the BLS rate of nonfatal assaults among health care workers was 8.8 cases per 10,000—almost four times higher than in the private sector. Among assault victims, 30% were government employees, even though they comprise only 18% of the U.S. workforce.

In each year from 1993 to 1999, 1.7 million incidents of violence occurred in the workplace. Twelve percent of all victims reported physical injuries, half of them requiring medical treatment. Less than half of incidents were reported to the police. Mental health professionals had an annual incidence rate of 68 per 1,000 workers compared to 12 for all workers. Nurses had an annual incidence rate of 22 per 1,000 workers.[8] In a study in a psychiatric facility in Washington State, 73% of staff members reported a minor injury related to an assault by a patient during the previous year; only 43% of those reporting moderate, severe, or disabling injuries due to such assaults had filed for workers' compensation. The survey found an annual assault incidence rate of 437 per 100 employees per year, whereas the reported incidence rate for the hospital was only 35, indicating substantial underreporting of assaults.[9]

Emergency department workers also face an increased risk of injuries from assaults by patients or their family members. Carrying of weapons in emergency departments creates the opportunity for severe or fatal injuries. California and Washington State have enacted standards requiring safeguards for emergency department workers. Since no department in a health care setting is immune from workplace violence, all departments should have violence prevention programs.

Environmental and organizational factors have been associated with patient assaults, including understaffed situations (especially during times of increased activity such as meal times), poor workplace security, unrestricted movement by the public around the facility, and the transport of patients. The presence of security personnel reduces the rate of assault. The rate of assault is increased when *(a)* administrators consider assault to be part of the job, *(b)* there is a high patient-to-worker ratio, and *(c)* work is primarily with patients with psychiatric disorders or with patients who have long hospital stays.

Many psychiatric settings now require that all care providers receive annual training in the management of aggressive patients, but few studies have examined the effectiveness of such training. Those that have done so have generally found improvement in nurses' knowledge, confidence, and safety after taking an aggressive behavior-management program.

Health care workplaces must be made safe for all workers through the use of engineering and administrative controls, such as security alarm systems; adequate staffing; and training.

NEEDLESTICK INJURIES

The most prevalent, least reported, and largely preventable serious risk health care workers face arises from their continuing use of inherently dangerous conventional needles and sharp

devices that lack an engineered injury protection feature. Unsafe needles transmit bloodborne infections to health care workers employed in a wide variety of occupations. Injuries can be dramatically reduced by eliminating unnecessary sharp devices and using sharp devices with engineered injury-protection features. (See Chapter 13.)

Percutaneous injuries continue to frequently occur in health care despite the promulgation in 1991 of the OSHA Bloodborne Pathogen (BBP) Standard. The physical and mental health consequences of transmission of a potentially fatal bloodborne infection have also remained high since then. The requirement under the BBP Standard that hepatitis B vaccine be made available free of charge to health care workers has greatly reduced the consequences of exposure to this pathogen. The advances in the treatment of human immunodeficiency virus (HIV) infection with postexposure prophylaxis has improved the prognosis for health care workers infected with HIV-contaminated blood. There is no vaccine or treatment for hepatitis C virus (HCV), and, therefore, health care workers continue to suffer life-threatening illness following exposure to HCV-contaminated blood. Therefore, all health care workers, not only those working in the acute care setting or those who traditionally handle needles on a regular basis, should receive every available protection from occupational exposure to blood and body fluids.

After a needlestick injury, the risk for the nonimmune health care worker of developing occupationally acquired hepatitis B virus (HBV) infection ranges from 2% to 40%, depending on the hepatitis B surface antigen (HB_sAg) status of the source patient. The risk of transmission from a positive source for HCV is between 3% and 10%,[10] and for HIV, 0.3%.[11] However, the risk of transmission increases if *(a)* the injury is caused by a device visibly contaminated with blood, *(b)* the device is used to puncture the vascular system, or *(c)* the stick causes a deep injury. All of these diseases are associated with significant morbidity and mortality. Only hepatitis B can be prevented by vaccine. Health care, laundry, and housekeeping workers are often engaged in tasks that create a potential for these high-risk needlestick injuries. (See Fig. 1-3 in Chapter 1.)

An estimated 600,000 to 800,000 needlestick injuries occur in the United States annually in health care, half of which are sustained by hospital-based, health care providers. Approximately half of all needlestick injuries are not reported. At an average hospital, workers incur approximately 30 needlestick injuries per 100 beds per year. Fifty-four percent of reported needlestick and sharp-object injuries involve nurses.[12] Annually, percutaneous exposure in the United States leads to an estimated 150 transmissions of HCV among health care workers. The annual death rate in the United States for health care workers from occupational infectious diseases was estimated, for 2002, to be 9 to 29 per 1 million workers, with 75 to 250 deaths from HBV (a number that is expected to markedly decline in future years due to HBV vaccine) and 5 to 10 deaths from HIV, HCV, and tuberculosis (TB) combined.[13]

In the past 20 years in the United States, 57 occupationally acquired HIV infections have been documented among health care workers. Due to reporting difficulties, this number grossly underestimates the number of actual occupationally acquired HIV infections. No new cases occurred between 1999 and 2009; approximately half of all cases occurred before 1991. Of all health care worker infections, 88% have resulted from percutaneous injuries—41% occurring after a procedure, 35% during a procedure, and 20% during disposal of equipment. Unexpected circumstances occurring during or after the procedure accounted for 20% of injuries.

There is a great emotional impact to a health care worker following a needlestick. Drug prophylaxis can be exhausting and debilitating. The emotional threat of having incurred a possible fatal disorder has a profound impact on the daily life of health care workers and their ability to perform their jobs, maintain stable relationships with their co-workers and family members, and have emotional balance. These emotional reactions may be manifest as symptoms of anxiety or posttraumatic stress disorder (PTSD).

Use of conventional sharp devices in health care today has been compared with the use of unguarded machinery many years ago in the industrial workplaces. Safer sharp devices have built-in integrated safety features that prevent needlestick injuries (Fig. 13-3). The term "safer needle device" is broad and includes many different devices, from those that have a protective shield over the needle to those that do not

use needles at all. Needles with integrated safety features are categorized as passive or active. Passive devices offer the greatest protection because the safety feature is automatically engaged after use, without the need for a health care worker to take any additional steps. An example of a passive device is a spring-loaded retractable syringe or self-blunting blood collection device. An example of an active safety mechanism is a sheathing needle that requires the worker to manually engage the safety sheath, frequently using the other hand and potentially resulting in another needlestick.

The passage of the federal Needlestick Safety and Prevention Act in 2000 has afforded health care workers better protection from this unnecessary and potentially fatal hazard. Not only does the Act amend the 1991 BBP Standard to require that safer needles be made available, but it requires employers to solicit the input of front-line health care workers when making decisions to purchase safe needles. While there has been widespread conversion to safety in some device categories (such as phlebotomy needles and intravenous catheters), relatively few safety devices have been used in others (such as laboratory equipment and surgical instruments). Between 1993 and 2001, percutaneous injury rates due to needlesticks in nurses decreased 51%, supporting the use of new technology in reducing percutaneous injury risk.[14]

LATEX ALLERGY

Within the first few years after promulgation of the 1991 BBP Standard, latex allergy, partly attributed to increased use of examination and surgical gloves required by the Standard, began to be reported by nurses and other health care workers. The prevalence of latex allergy among health care workers is estimated to be between 5% and 18%, with atopic workers at greater risk. People with latex allergy are also more likely to develop sensitivity to other allergens, especially certain food items.

Three types of reactions can occur in persons using latex products: irritant (nonallergic) contact dermatitis, allergic contact dermatitis, and latex allergy. The most common reaction to latex products is irritant contact dermatitis, with dry, itchy, irritated areas on the skin, usually of the hands. This reaction is caused by skin irritation from using gloves and possibly by exposure to other workplace products and chemicals. Allergic contact dermatitis (delayed hypersensitivity dermatitis) results from exposure to chemicals added to latex during harvesting, processing, or manufacturing. These chemicals can cause skin reactions similar to those caused by poison ivy.

Latex allergy (immediate hypersensitivity) can be more serious. Certain proteins in latex may cause sensitization. Although the amount of exposure needed to cause sensitization is not known, exposures at even very low levels can trigger allergic reactions in some sensitized individuals. Mild reactions to latex include skin redness, itching (urticaria) or hives, and runny nose, sneezing, itchy eyes, and scratchy throat. More severe reactions include asthma and anaphylaxis.

In 1997, NIOSH recommended the use of powderless, low-protein latex gloves only when protection from infectious agents is needed, and, when latex gloves are used. Substituting nonlatex or powder-free national rubber latex for powdered gloves reduces the incidence of suspected latex allergy and, specifically, latex-related occupational asthma. Hospitals with programs or policies to reduce employee exposure to latex have reported a 40% decrease in latex-related symptoms. A Belgium study found incident cases of definite and probable natural rubber latex-induced occupational asthma markedly decreased from 1999 onward.[15]

CHEMICAL HAZARDS

Health care workers are exposed to *(a)* a wide range of chemical disinfectants, anesthetic waste gases, and hazardous drugs (such as chemotherapetic medications) that are known to cause adverse health effects, and *(b)* others for which there has been inadequate or no testing. The average hospital contains about 300 chemicals—twice the number of the average manufacturing facility. Among disinfectants, formaldehyde is a probable human carcinogen and has been linked to occupational asthma in hospitals. Glutaraldehyde (Cidex), a widely used cold-sterilization solution for disinfecting and cleaning heat-

sensitive instruments, such as endoscopes, and for fixing tissues in histology and pathology labs, is a respiratory irritant and sensitizer. Ethylene oxide, a gas sterilant, is a neurotoxin, carcinogen, and reproductive health hazard, and has been associated with lens opacities among workers responsible for changing ethylene oxide cylinders. Thousands of health care workers were exposed to harmful levels of this gas before the OSHA standard for ethylene oxide was issued in 1984. It continues to be of concern to hospital workers in central supply because of leaks from distribution lines, especially when gas cylinders are being changed. Of particular concern is the fact that the odor threshold for ethylene oxide (260 ppm) is well above the OSHA permissible exposure limit (1.0 ppm) and the NIOSH recommended exposure limit (0.1 ppm), and approaches the immediately dangerous to life and health concentration level. In addition, ethylene oxide is highly flammable and therefore poses a dangerous fire and explosion risk.

Anesthetic agents, used in large amounts in hospitals, are a threat to health care workers when operating room scavenging systems are poorly maintained. Health care workers are also exposed when patients are transferred to the recovery room and exhale anesthesia gases. Specially designed, nonrecirculating, general ventilation systems, with adequate room-air exchange, are necessary in these areas.

Therapeutic agents associated with adverse health effects among workers who handle and administer them include hazardous drugs, such as antineoplastic agents, which are known to cause adverse reproductive effects, cancer, and other adverse effects. Safe handling guidelines have been published by the National Institutes of Health, NIOSH, and OSHA to help control dermal and inhalation exposures associated with the mixing and administration of these drugs. These guidelines state that these drugs should be prepared in a centralized area by trained individuals under a Class II(B) or Class III Biological Safety Cabinet. Proper glove material designated for use with hazardous drugs should be used because most of these substances easily penetrate regular latex gloves. Aerosolized medications pose threats because of how these drugs are administered. One aerosolized drug, ribavirin, is of particular concern because it is a potential human teratogen. Use of aerosolized medication requires use of engineering controls, such as specially designed booths and worker respiratory protection, including compliance with all elements of the OSHA respiratory protection standard.

ORGANIZATION OF WORK

Organization of work refers to management and supervisory practices as well as production processes and their influence on the way work is performed. Perhaps no other single factor influences worker injury and illness rates more than the manner in which work is organized and staffing decisions are made (Fig. 36-6). Few industries in the United States have undergone more sweeping changes in the organization of work over the past two decades than health care. Macro-level changes in the organization of the work of health care delivery have included organizational mergers, downsizing, changes in employment arrangements (such as contract work), job restructuring and redesign, and changes in worker–management relations. Many of these changes accompanied the movement toward managed care, the priority given to cost containment, and conversions from nonprofit to for-profit health care institutions. Health care reform, which is likely to have a major impact on the way in which health care work is organized and performed, provides an opportunity to strengthen worker health and safety protections.

Widespread concern about inadequate nursing staffing levels in health care facilities and its adverse impact on health care errors led to an Institute of Medicine (IOM) report that concluded that the work environment of nurses needs to be substantially transformed to better protect patients from health care errors.[16] The report recommended changes in how nurse staffing levels are established, mandatory limits on nurses' work hours, involvement of nurse leaders in all levels of management, and nursing staff input on decisions about work design and implementation. An earlier IOM report, which concluded that most medical errors result from basic flaws in the way the health system is organized, recommended that health care organizations create environments in which safety is

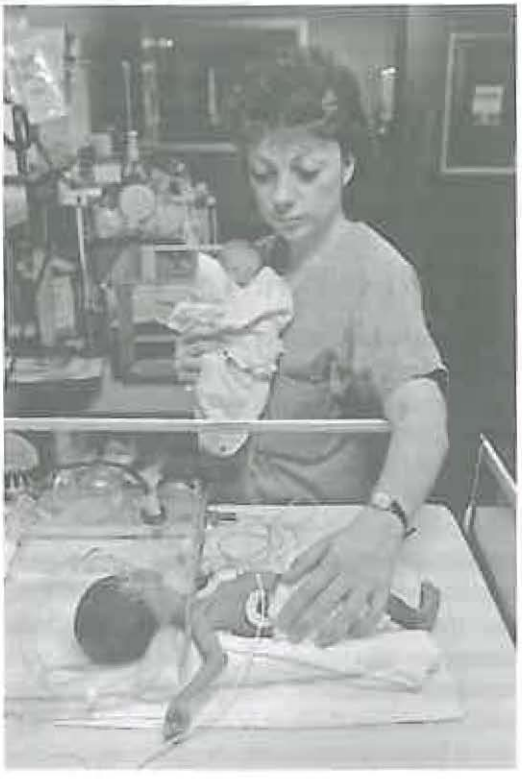

Figure 36-6. A nurse working in the neonatal intensive care unit carries one infant while attending to another. Inadequate staffing can increase nurses' occupational stress. (Photograph by Earl Dotter.)

a top priority and a feature of job design and working conditions.[17]

Despite the increased focus on patient care and nurse staffing, few studies have examined the relationship between organization of work and worker injury and illness. One study, which examined OSHA-200 worker injury and illness logs at many hospitals, found that, when nursing staff was reduced by 9%, a 65% increase in reported injuries and illnesses occurred—largely due to needlestick and back injuries.[18]

LEGISLATIVE AND REGULATORY ACTIONS TO PROTECT HEALTH CARE WORKERS

Legislation, regulations, and voluntary guidelines to protect health care workers have been slow in coming, and inadequate in their coverage. In 1958, the American Medical Association and American Hospital Association issued a joint statement in support of worker health programs in hospitals. In 1977, NIOSH published criteria for effective hospital occupational health programs. In 1982, the CDC published the *Guideline for Infection Control in Hospital Personnel*, which focused on infections transmitted between health care workers and patients—not only health care workers' risks of contracting infectious diseases.[19] CDC guidelines for Blood and Body Fluid Precautions (1983), Universal Precautions (1987),[20] and Standard Precautions (2007),[21] the latter of which combines the major features of Universal Precautions (UP) and Body Substance Isolation (BSI), were published to provide guidance to health care workers.

In 1984, OSHA promulgated its first health care worker–specific standard, covering the use of ethylene oxide. This was followed by the BBP Standard in 1991 and its revision in 2000. OSHA standards addressing tuberculosis and ergonomics were completed, but reversed. At least 10 states have enacted nurse-staffing legislation to protect both patients and workers. Despite claims that the nursing shortage has prevented employers from finding nurses, a California law has had the opposite impact: The wait time for nurses in California to obtain or renew a license increased from weeks to months—evidence that nurses are reentering the field of nursing in response to a more human and patient-friendly environment. Recent legislative efforts, including the passage of safe patient handling laws in nine states and the introduction of legislation in many states and at the federal level, may finally begin to reverse the high rates of MSDs in health care workers. Despite progress in decreasing exposure to bloodborne infections and unsafe patient transfers, it is unlikely that the high rates of occupational injuries and illnesses among health care workers will be reduced without adoption and strong enforcement of new federal regulations addressing the main hazards facing health care workers.

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FURTHER READING AND WEB SITES

American Nurses Association (ANA) Web site. http://www.nursingworld.org.dlwa/osh/.
This Web site offers information on cutting-edge issues of primary concern to U.S. nurses. It contains information on latex allergy, workplace violence, pollution prevention in health care, and other topics. It provides links to relevant Web sites.

Center to Protect Workers' Rights (CPWR). The construction chart book: the U.S. construction industry and its workers (3rd Edition). Silver Spring, MD: CPWR, 2007. Available at: http://www.cpwr.com/publications/page%2049.pdf.
An excellent compendium of statistics related to the safety and health of construction workers.

International Health Care Worker Safety Center, Charlottesville, Virginia. http://www.healthsystem.virginia.edu/internet/epinet.

The Center's Web site contains up-to-date information from its national needlestick injury surveillance program.

National Institute for Occupational Safety and Health. http://www.cdc.gov/niosh/homepage.html.

This NIOSH Web site has special sections for health care, agricultural, and construction workers. Especially useful documents on health care include the following: Violence: Occupational Hazard in Hospitals at http://www.cdc.gov/niosh/2002-101-html; Latex Allergy: A Prevention Guide at http://www.cdc/niosh/93-113.html; http://www.cdc/niosh/02-116pd.html. For agricultural workers and construction workers, there are electronic databases of available materials that are periodically updated: The National Agricultural Safety Database at http://www.cdc.gov/niosh/nasd.html and the Electronic Library of Construction Safety and Health at http://www.cdc.gov/niosh/elcosh.html.

Occupational Safety and Health Administration. Guidelines for preventing workplace violence for health care and social service workers. Washington, DC: NIOSH, 1996. Available at: http://www.osha.gov.

This document provides a succinct discussion of the background of the problem and a detailed description of the critical elements of a violence prevention program. The document provides excellent examples of how to respond to these performance-based guidelines, including a staff assault survey, checklists, and forms.

The findings and conclusions in this chapter are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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