

Injuries and Occupational Safety

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Occupational injuries are caused by acute exposure in the workplace to safety hazards, such as mechanical energy, electricity, chemicals, and ionizing radiation, or from the sudden lack of essential agents, such as oxygen or heat. Examples of events that can lead to worker injury include motor-vehicle crashes, assaults, falls, being caught in parts of machinery, being struck by tools or objects, and contact with electrical energy. Resultant injuries include fractures, lacerations, abrasions, burns, amputations, poisonings, and damage to internal organs.

Occupational and nonoccupational injuries represent a serious public health problem (Box 19-1). More than 4,830 workers died from occupational injuries in the United States in 2015.¹ Another 3.5 million workers sustained nonfatal injuries in 2015;² this estimate is conservative because it relies on employer reporting, excludes important groups of workers (such as workers who are self-employed and workers on small farms), and may miss counting many cases.³ An estimated 2.5 million workers were treated in emergency departments for work-related injuries and illnesses in 2014, with approximately 4% of them being hospitalized immediately or transferred to another hospital, such as a trauma

or burn center.⁴ The direct cost of serious occupational injuries in the United States in 2014 was estimated at \$59.9 billion,⁵ an amount that includes only wages and medical payments to workers whose injuries resulted in more than 6 days away from work.

CAUSES OF INJURY

Although the immediate cause of injury is exposure to energy or deprivation from essential agents (such as oxygen deficiency), injury events arise from a complex interaction of factors associated with materials and equipment used in work processes, the work environment, and the worker. These factors include safety hazards in workplaces or work settings; hazards and safety features of machinery and tools; the development and implementation of safe work practices; the organization of work; the design of workplaces; the safety culture of the employer and workplace safety climate; availability and use of personal protective equipment (PPE); demographic characteristics of workers; training, experience, and knowledge of workers; and economic and social factors.

Box 19-1. Injuries Are a Major Public Health Problem

In addition to the workplace, injuries occur at home and school, while traveling, and during recreation. In the United States, injuries are the leading cause of death for persons aged 1 to 44 years, surpassing deaths from cancer, heart disease, and infectious diseases. In 2015 in the United States, 214,008 injury deaths occurred (age-adjusted rate of 64 per 100,000 persons). Injuries contributed to more than 3.5 million years of potential life lost before age 65. In 2015, an estimated 32 million nonfatal injuries required treatment in an emergency department (age-adjusted rate of 9,948 per 100,000 persons).¹

Many injury causes are common in multiple environments, such as the workplace and home; others are more common in the workplace. Transportation events, violence, falls, and being struck by objects are examples of injury causes that are common in multiple settings; machinery, electrocutions, explosions, and overexertion injuries are more common in the workplace. Strategies

for reducing and preventing injuries in multiple settings include changes to the environment (such as changes in roadway design), regulatory policy (such as specifying product safety parameters), and educational approaches. Broad injury prevention measures, such as those focused on improving roadway safety, improve workplace safety. Injury prevention measures in the workplace complement those occurring in other settings.

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CASE 1

A 28-year-old male temporary worker was fatally injured while cleaning and sanitizing a machine at a company that manufactured food products. Although the incident was not witnessed, the victim was reportedly cleaning the augers inside the bottom of the machine's tub while they were rotating. Both of the victim's arms became caught in the augers. A coworker heard the victim yell and noticed him being pulled into the machine. The coworker then stopped the machine via an emergency stop button while another coworker called emergency medical services. The victim was transported to a local hospital where he was pronounced dead. Subsequent investigation found several inches of water mixed with food product on the floor, which made it slippery, and floor drains clogged with food product, which prevented the water from draining. It is likely the slippery floor caused the worker to fall into the machine's rotating augers.⁶

This case illustrates how occupational injuries can be caused by a variety of factors and circumstances, some of which are clearly established while others are presumed:

- The victim was employed through a temporary staffing agency, which apparently

did not provide him with training on safety hazards associated with his work tasks or on safe work practices and did not require the company to provide such training. (See Chapter 2.)

- The company provided new workers with orientation and in-house on-the-job training that focused on good manufacturing practices but did not provide comprehensive safety training on hazards in the workplace or on safe work practices. (See Chapter 4.)
- The company did not have a comprehensive written health and safety program. It provided lockout/tagout training only to permanent maintenance workers, not to temporary employees.
- The company had a manager responsible for health and safety, but he spent only 2 hours weekly on health and safety. The company's health and safety committee was defunct and therefore had not been meeting.
- The process for cleaning and sanitizing the machine included removing the tub cover and spraying water into the equipment after turning it on, creating the possibility of workers coming into contact with moving parts.
- The floor, with several inches of water due to clogged floor drains, was slippery, which

increased the likelihood of workers falling into the machine.

- The equipment did not have engineering controls that could help prevent injuries to workers cleaning it, such as an interlock into the auger power control circuit to shut down or prevent start-up of the auger motors when the tub cover was removed.

This case demonstrates how injury events can arise from a complex array of factors, not all of which contribute equally. In addition, the responsibilities for a safe work environment and safe work practices are not borne equally by all involved parties. Employers bear the greatest responsibilities, as they are responsible for providing a safe work environment, including the identification of potential safety hazards and the implementation of hazard controls and safe work practices and procedures. Workers are responsible for following established procedures, although they should be empowered by supervisors to report problems with established procedures and provided with the training and support to identify and report safety hazards to employers. This case also highlights how multiple employer arrangements can endanger worker safety when workers are hired by a temporary staffing agency but work in an environment controlled by another employer. (The Occupational Safety and Health Administration has issued a series of guidance documents to clarify the responsibilities that employers have in this type of situation.⁷)

THE EPIDEMIOLOGY OF INJURIES

Occupational injuries are not random events. They cluster or are associated with specific types of workplaces and jobs, workplace exposures, and worker characteristics. Because occupational injuries are not random, they can be anticipated and steps can be taken to prevent them.

Epidemiologic data allow those involved in injury prevention efforts to target groups and settings with high numbers or rates of occupational injuries and to anticipate and take steps to prevent injuries in specific workplaces or work settings. Epidemiologic data on fatal and

nonfatal occupational injuries differ and thus are addressed separately. Both categories of injuries require attention—fatal injuries, because they represent the most severe consequence of occupational injury and are devastating to families, communities, and workplaces, and nonfatal injuries, because of the sheer volume and aggregate costs to workers, families, employers, and society as a whole.

Fatal Injuries

In the United States, data on fatal occupational injuries are considered to be very complete. Beginning in 1992, the U.S. Bureau of Labor Statistics (BLS) began collecting data through the Census of Fatal Occupational Injuries (CFOI), which uses multiple sources of data and involves verification of the work-relatedness of deaths.¹ A less complete system based only on death certificates, the National Traumatic Occupational Fatalities (NTOF) system, provides additional data for the years 1980 through 1995.⁸ Both CFOI and NTOF provide data for each state and for the United States as a whole. Data, such as medical-examiner records, also exist at the state level. (See Chapter 6.)

In 2015 there were 4,836 fatal occupational injuries in the United States—3.4 fatal occupational injuries for every 100,000 U.S. full-time equivalent workers.¹ The distribution and risks for fatal occupational injury differ by demographic characteristics of workers. Men account for more than 90% of occupational fatalities and have occupational fatality rates approximately 10 times higher than those for women.⁸⁻⁹ In 2015, of all occupational fatal injuries, 67% were among white non-Hispanic workers, 19% among Hispanic workers, 10% among black non-Hispanic workers, and 2% among non-Hispanic Asian workers.⁹ Of all fatal occupational injuries, 19% occurred among workers born in other countries, with the largest proportion born in Mexico.¹ An analysis of fatal occupational injuries from 2005 through 2009 found that high rates, by race, ethnicity, and foreign birth, were largely associated with work in high-risk industries, such as agriculture, mining, transportation, and construction.¹⁰ Of all fatal occupational injuries in 2015, 57% occurred to workers between 25 and 54 years of age, 8% to

workers younger than 25, and 35% to workers 55 and older.¹¹ Rates of fatal occupational injury generally increase with age, with the highest rates among workers 65 and older.^{1,8-9} The youngest and oldest workers present both challenges and opportunities for occupational injury prevention (Box 19-2).

Box 19-2. The Youngest and Oldest Workers Present Challenges and Opportunities for Prevention

The U.S. workforce is characterized by involvement of workers from early adolescence to beyond traditional retirement ages. The United States is somewhat unique among industrialized nations in the high participation of youth less than 18 years of age in the workforce. As the U.S. population has aged and people have lived longer than in the past, the number of older workers has increased—and this number is expected to continue to grow. The number of workers 55 years and older increased 47% between 2004 and 2014, and it is expected to increase an additional 20% by 2024 to more than 40 million.¹ In 2016, there were nearly 5 million workers 16 to 19 years of age and 1.6 million workers 75 years and older in the United States.²

Because of their biologic, social, and economic characteristics, the youngest and oldest workers have unique patterns and risks for work-related injuries. While younger workers have lower rates than older workers for fatal injuries, their rates for nonfatal occupational injury are higher. The higher rates of nonfatal injury are frequently attributed to less experience and training on safety hazards in the workplace. In contrast, the oldest workers have the highest rates of fatal occupational injury, lower rates of nonfatal injury, and longer recovery times once injured. Decreased physical ability to tolerate and recover from injuries may account for the longer recovery times and increased fatality rates. While normal decrements in health associated with aging, such as reductions in visual acuity and slower reaction times, would theoretically lead to increased injuries among older workers, it would appear that work and life experiences contribute to the lower rates of nonfatal occupational injury among older workers. Furthermore, older workers may be assigned to less physically demanding tasks.

It is important to ensure that employers provide new workers with training on the specific safety hazards in their work environment and guidance on how to safely perform their jobs. In addition, there is potential value in providing youth with basic training on occupational safety before they enter the workforce, as a means of helping to keep them safe in their first jobs, and potentially contributing to a more safety conscious generation of new workers. Along these lines, NIOSH and its partners

In 2015, of all fatal occupational injuries, 78% were among wage and salary workers; the remainder were among self-employed workers, whose fatality rate is more than four times greater than that of wage and salary employees.⁹ In 2015, 17% of the deaths occurred among workers identified as contractors.¹ From 2011 to

have designed curricula that can be integrated into high-school programming or be used in other group settings, such as in apprentice training.³ Several government and private-sector entities have also developed educational materials to increase the safety of young workers up to 24 years of age.

At the other end of the age spectrum, older workers bring a wealth of experience and perspective to the workplace. As the workforce continues to age, it is important to understand workplace programs and policies that reduce the risk for injury among an older population facing the realities of the aging process and to make reasonable accommodations to increase the safety of older workers. Modifying work tasks to account for age-related decrements in functioning may have the added benefit of increasing safety for workers of all ages.

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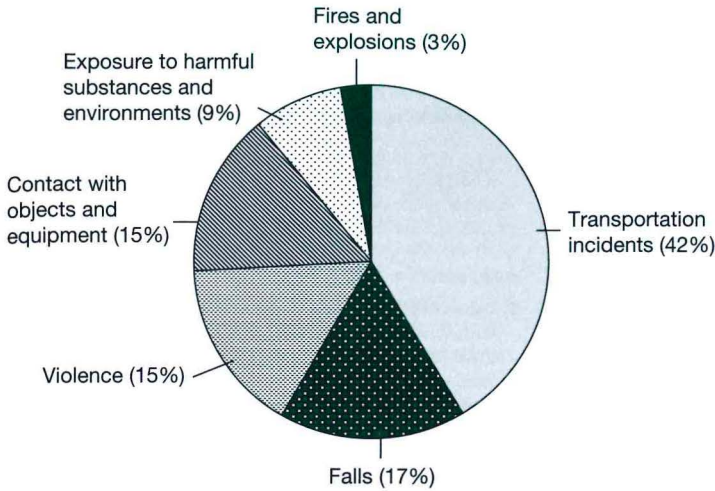


Figure 19-1. Events or exposures leading to occupational injury deaths, United States, 2015. (Source: Bureau of Labor Statistics, U.S. Department of Labor.)

2015, most fatally injured contractors were male and identified as wage and salary workers (as opposed to self-employed workers), and many worked in construction.¹² (See Chapter 32B.)

Transportation-related events accounted for 42% of the 4,836 occupational injury deaths in the United States in 2015 (Figure 19-1).¹ These

events involved motor vehicles and mobile equipment, such as tractors and forklifts; occurred on and off the highway; and included pedestrians and bystanders as well as operators and drivers. Work-related motor-vehicle crashes provide unique challenges and opportunities for prevention (Box 19-3). Falls, mostly to a lower

Box 19-3. Unique Challenges for Prevention of Work-Related Motor Vehicle Deaths and Injuries

Motor vehicle crashes are the leading cause of occupational injury deaths in the United States. Between 2003 and 2015, crashes killed 16,005 workers who were drivers or passengers in motor vehicles, averaging more than three deaths daily¹. Truck drivers account for more crash fatalities than any other occupation (46% in 2015²), and they have the highest rates of occupational deaths due to motor vehicle crashes. However, crash risk affects workers in all industries and occupations, whether they drive heavy or light vehicles on the job and whether driving is a main or incidental job duty.

Preventing work-related motor vehicle crashes is a responsibility shared by employers and workers and requires a multipronged approach to reduce risks related to the driver, the vehicle, and the work environment. Although employers cannot exert full control over the conditions their workers face while on the road, they can take a number of steps to help keep their workers safe when driving, such as:

- Promoting road safety by the highest levels of company leadership
- Conducting a thorough assessment of road risks drivers face
- Considering if work can be accomplished without traveling by motor vehicle or use safer modes of travel, such as air or rail

- Implementing and enforcing policies for mandatory use of seat belts
- Ensuring that workers assigned to drive on the job have valid driver's licenses appropriate for the types of vehicles they drive
- Conducting motor vehicle record checks for prospective employees and periodic rechecks after hiring
- Providing driver training at the time of hiring and periodic refresher driving training
- Providing fleet vehicles with high safety ratings based on crash testing
- Selecting vehicles with advanced safety features, such as forward-collision and lane-departure warning systems, automated emergency braking, and adaptive cruise control
- Maintaining complete and accurate records of workers' driving performance
- Reviewing motor vehicle crashes to determine if changes in policies and practices are needed
- Incorporating fatigue management into motor vehicle safety programs
- Avoiding requiring workers to drive irregular hours or to extend their workday far beyond their normal working hours as a result of driving responsibilities
- Establishing schedules that allow drivers to obey speed limits and follow applicable hours-of-service regulations
- Preventing distracted driving by banning text messaging and the use of hand-held phones while driving

(continued)

Box 19-3. (Continued)

- Setting safety policy in accordance with state graduated-driver licensing laws so that company operations do not place younger workers in violation of these laws
- Offering periodic vision screening and assessment of physical health for all workers for whom driving is a primary job duty.

Many of these recommendations are included in the American National Standards Institute/American Society of Safety Engineers (ANSI/ASSE) Z15.1–2017 standard, *Safe Practices for Motor Vehicle Operations*.³ This voluntary consensus standard provides minimum guidelines for employers to develop a motor vehicle safety program. These guidelines are meant for use by employers with vehicle fleets of all sizes and vehicle types.

Workers can also take steps to increase their safety while driving in the performance of their work, including:

- Following employer policies and traffic laws
- Using seat belts at all times and insisting that passengers do the same
- Not texting or using a hand-held phone while driving
- Avoiding placing or taking cell phone calls while operating a motor vehicle
- Ensuring they are well-rested before operating a motor vehicle at work

- Talking to their healthcare provider about whether medical conditions or medications may affect their ability to drive safely
- Maintaining work vehicles in good operating condition.

Source: Preventing work-related motor vehicle crashes. DHHS (NIOSH) Publication No. 2015-111, Cincinnati, OH: NIOSH 2015. Available at: <http://www.cdc.gov/niosh/docs/2015-111/pdfs/2015-111.pdf>. Accessed September 14, 2016.

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level, accounted for 17% of the fatalities in 2015.¹ Violence accounted for 15% of the fatalities, with most involving homicides and many involving suicides. Assaults against workers occur in a variety of work situations, and consequently prevention strategies vary (Box 19-4). Contact with objects or equipment accounted for 15% of the fatalities, including being struck by falling objects, being caught in running equipment or machinery, and being caught in or crushed by collapsing materials, such as in trench cave-ins or collapsing buildings. Rapid technological advances in robotic machinery require vigilant attention to safety implications for workers (Box 19-5). Exposure to harmful substances or environments, such as electric current, temperature extremes, hazardous substances, and oxygen deficiency, accounted for 9% of fatalities. Fires and explosions accounted for 3% of the fatalities.¹ Demographic characteristics vary; for example, homicide accounts for a higher proportion of deaths among women than in men.^{1,8}

The incidence of occupational injury deaths varies by industry sector (Table 19-1), with the most deaths in 2015 occurring in the construction sector and the highest fatality rates in agriculture, forestry, fishing and hunting; transportation and warehousing; and mining, quarrying, and oil and gas extraction.¹⁹ Numerous specific industries and occupations have injury rates far above the average for all industries and occupations. For example, occupations with fatality rates (deaths per 100,000 full-time equivalent workers) more than 10 times higher than the national average in 2015 include logging workers (133), fishers and related fishing workers (55), aircraft pilots and flight engineers (40), roofers (40), and refuse and recyclable materials collectors (39).^{1,9}

Nonfatal Injuries

There is no single data system in the United States that collects data on all nonfatal occupational injuries. The two primary national sources

Box 19-4. Workplace Violence: A Complex Workplace Injury Phenomenon

Homicide is a leading cause of fatal occupational injuries, and workplace violence accounts for many nonfatal injuries each year. Because of news coverage of sensational and more “newsworthy” events, many assume that disgruntled coworkers and former employees account for the bulk of these injury statistics. In reality, violence caused by coworkers or former employees is a relatively small part of the workplace violence problem in the United States. Most work-related violence in the United States is associated with crime, such as robbery, and violence from clients, customers, or patients.

Violence in the workplace has been categorized into four different types of events:

- *Type I: Criminal Intent:* These situations are typically associated with crimes such as robbery, shoplifting, and loitering. A pre-existing relationship does not exist between the employee and the perpetrator, and the perpetrator does not have a legitimate reason for being in the workplace.
- *Type II: Customer or Client:* These situations involve customers or clients who have a legitimate reason for being in the workplace. The violence is associated with a business transaction or service. Perpetrators include customers, clients, patients, and inmates.
- *Type III: Worker-on-Worker:* These situations involve violence between coworkers or violence perpetrated against an employee by a former employee.
- *Type IV: Personal Relationship:* In these situations, the perpetrator has a pre-existing relationship with the employee and the violence is associated with the

relationship rather than the business. These situations include acts of domestic violence against employees while they are at work.

Workplace violence occurs in a variety of workplaces and occupations, although there are some worker groups at increased risk for the more common Type I and II events, including police and corrections officers, taxi drivers, healthcare providers, and employees in retail settings.

While workplace violence is a complex phenomenon, there are a variety of strategies that employers and workers can use to reduce the risks for violence—some specific to work settings and tasks and others more general. Workplace violence prevention strategies include modifying the work setting and tasks to reduce the risks for robbery and/or assault (such as by posting signs in retail settings that minimal cash is kept on hand, providing physical barriers between employees and potential criminals or violent clients, ensuring good lighting, and using surveillance cameras and/or security guards); establishing workplace policies for “zero violence tolerance” and procedures for reporting and following up on all threats or violent acts; and training employees on how to handle criminals or violent customers or clients.

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Box 19-5. Advances in Robotics Require Vigilance to Ensure Worker Safety

Robots are machines that are programmable, have parts that move in multiple axes, and, once activated, work automatically. Industrial robots have been used in manufacturing for decades and have contributed to productivity and worker safety. Robots can have more strength and precision than humans and eliminate the need for workers to be in dangerous environments and perform dangerous tasks. The traditional strategy for ensuring worker safety around industrial robots has been to keep robots and workers separated and to ensure that robots shut down when workers are present nearby.¹⁻³

With advances in technology, we are moving into an era where robots may work alongside workers, be worn by workers, and, in the case of autonomous vehicles, envelope workers. Traditional paradigms that keep workers separated from robots will not always apply.

Robots are increasingly mobile and are no longer confined to caged-off work areas. Robots are now present and

under development across the industrial spectrum. In the past few years, a new type of robot has emerged: the collaborative robot that works alongside workers and sometimes requires interaction with them. Such robots are now being used on manufacturing assembly lines and in construction work, such as laying bricks. Examples of mobile robots include automated tractors in agriculture, remote-controlled robots that inspect pipelines and bridges, and robots programmed to deliver materials in hospitals and hotels. The military has been testing powered exoskeletons that can be worn by soldiers to increase strength, endurance, and speed in labor-intensive construction and maintenance tasks and on the battlefield. Robots, including drones that automate labor-intensive inventories in warehouses and deliver goods, are now being pilot-tested, as are autonomous commercial trucks and transit vehicles.

Advances in the applications of robotics in the workplace have the potential to increase worker safety by using robots rather than workers in dangerous environments and tasks and using robots to reduce physical stresses on

(continued)

Box 19-5. (Continued)

workers. However, increased interaction between robots and workers presents safety risks for workers and others. Job safety analysis and site hazard assessments are necessary to ensure that risks to workers and the public are identified, that engineering controls are implemented to prevent injuries, and that administrative controls, such as worker training, are used to ensure that workers and others understand the operation of robots, associated risks, and safety measures. Robot safety standards are being developed and updated. It is critical that these standards keep pace with rapidly advancing robot technologies so that the potential of robots is realized while the safety of workers is protected.

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Table 19-1. Number and Rate of Fatal Occupational Injuries, by Industry Sector, United States, 2015

Industry Sector	Number of Fatalities	Fatality Rate*
Construction	937	10.1
Transportation and warehousing	765	13.8
Agriculture, forestry, fishing and hunting	570	22.8
Professional and business services	477	3.0
Government	457	1.9
Manufacturing	353	2.3
Retail trade	269	1.8
Leisure and hospitality	225	2.0
Other services, except public administration	202	3.0
Wholesale trade	175	4.7
Educational and health services	139	0.7
Mining, quarrying, and oil and gas extraction	120	11.4
Financial activities	83	0.9
Information	42	1.5
Utilities	22	2.2
Total	4836	3.4

* Rate per 100,000 full-time equivalent workers.

Source: Bureau of Labor Statistics. Census of Fatal Occupational Injuries Charts, 1992-2015 (revised data). Washington, DC. Available at: <http://www.bls.gov/iif/oshwc/cfoi/cfch0014.pdf>.

of data on nonfatal work-related injuries are data from the BLS annual survey of employers³ and from emergency departments.⁴ Neither system is designed to capture all work-related injuries and both have limitations. The BLS survey is based

on employer reports of injuries documented in records required by the Occupational Safety and Health Administration (OSHA). Based on the BLS survey, there were an estimated 3.5 million occupational injuries in 2015.² The BLS survey excludes the self-employed, farms with fewer than 11 employees, and federal government employees, and it may miss many cases that should be counted.³ Data on worker demographics and the circumstances of injuries are available only for lost workday cases in the BLS survey.¹³ The emergency department system collects data on injuries treated in a nationally representative sample of emergency departments, with an estimate of 2.8 million (\pm 397,000) occupational injuries and illnesses in 2014.⁴ The identification of these cases requires documentation in the emergency department record that the injury was work-related. Research on the completeness of the emergency department data has not been conducted, and information on industry and occupation are not regularly available in the emergency department data. Data collected in both systems overlap and are not mutually exclusive. Illnesses, such as dermatitis, are included in both the emergency department data and lost workday data from the BLS employer survey, but they represent less than 15% of cases in both systems.⁴ Although the data from the BLS survey and emergency departments have limitations and undoubtedly underrepresent the true burden of occupational injuries, they are likely to represent the majority of the more-serious injuries,

and they provide useful information on epidemiologic patterns of injury.

Although not as dramatic as for fatal injuries, differences are seen across demographic categories for nonfatal injuries. Men accounted for approximately 64% of nonfatal work-related injuries treated in emergency departments in 2014 and approximately 75% of the hospitalizations.⁴ In 2015, men accounted for 61% of employer-reported injuries requiring days away from work (lost worktime injuries), had a rate about 24% higher than women, and had injuries that, on average, required more time away from work.¹³ In 2014, most injuries treated in emergency departments (51%) were among white, non-Hispanic workers, with fewer among Hispanic workers (10%) and black, non-Hispanic workers (11%).⁴ About 66% to 68% of nonfatal injuries occur among workers 25 to 54 years of age.^{4,13} Those younger than 25 account for about 18% of injuries treated in emergency departments⁴ and 10% of lost work-time injuries.¹³ Workers older than 54 account for 15% of injuries treated in emergency departments⁴ and 22% of lost work-time injuries reported by employers.¹³ Age-group-specific rates of nonfatal occupational injuries follow patterns that vary according to data source. In the emergency department data for 1998 to 2007, workers 16 to 24 years of age were found to have rates about double those of older groups.¹⁴ In contrast, in employer-reported data, rates are similar by age group and do not follow a clear pattern.¹³ The

median number of days away from work, based on employer-reported data, was 8 in 2015, with the median days increasing steadily from a low of 4 days for workers 14 to 15 years of age to a high of 14 days for workers 65 and older.¹³

In 2015, of employer-reported cases, 10% occurred among employees who had worked for less than 3 months for the employer, 17% among employees with 3 to 11 months of service, 31% with 1 to 5 years of service, and 40% with more than 5 years of service.¹³ Most employer-reported injuries requiring time away from work in 2015 occurred Monday through Friday (85%),¹⁵ and when reported, 62% occurred between 8:00 A.M. and 4:00 P.M.¹⁶ Of all employer-reported injuries, 64% occurred between 2 and 8 hours into the work shift, with the largest proportion (26%) occurring 2 to 4 hours into the shift.¹⁷

The types of events leading to nonfatal occupational injuries follow a different pattern than fatal occupational injuries. The most common events resulting in nonfatal occupational injuries include contact with objects and equipment, bodily reaction and exertion, and falls.^{4,13} Figure 19-2 shows the distribution of nonfatal occupational injuries treated in emergency departments in 2014. Demographic characteristics vary; for example, bodily reaction and exertion, as well as falls, account for a higher proportion of injuries among women than in men.⁴

The number and rate of nonfatal injuries by industry division vary greatly from the number

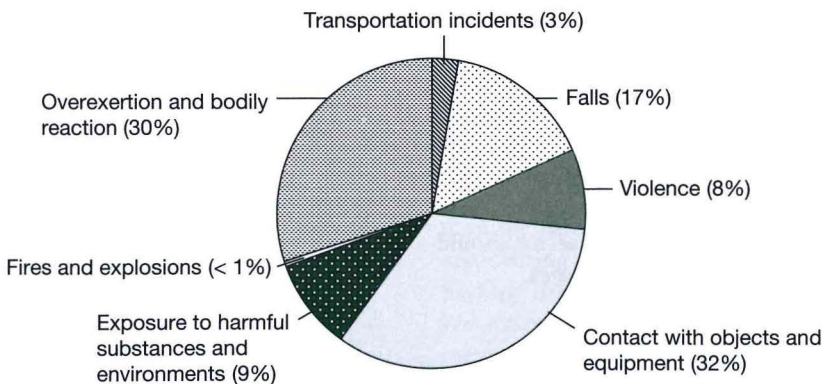


Figure 19-2. Events or exposures leading to occupational injuries treated in emergency departments, United States, 2014. (Source: NIOSH. Work-related injury statistics query system, <http://wwwn.cdc.gov/wisards/workrisqs/>. Unpublished queries by John Myers on June 19, 2017.)

Table 19-2. Number and Rate of Nonfatal Occupational Injuries Reported by Employers, by State and Local Government and Private Industry Sector, United States, 2015

Industry Division	Number of Injuries	Injury Rate*
State and local government	705,200	4.8
Education and health services	599,600	3.8
Manufacturing	425,700	3.4
Retail trade	399,600	3.4
Leisure and hospitality	322,300	3.3
Professional and business services	201,800	1.3
Transportation and warehousing	194,200	4.4
Construction	199,600	3.4
Wholesale trade	170,200	3.0
Financial activities	75,400	1.0
Other services, except public administration	70,000	2.3
Agriculture, forestry, fishing and hunting	53,000	5.4
Information	30,900	1.2
Mining, quarrying and oil and gas extraction	12,100	1.4
Utilities	11,000	2.0
Total	3,470,600	3.1

* Rate per 100 full-time equivalent workers.

Source: Bureau of Labor Statistics. Employer-reported workplace injuries and illnesses—2015. News Release USDL 16-2056. Washington, DC: BLS. Available at: <http://www.bls.gov/news.release/osh.nr0.htm>.

and rate for injury deaths (Table 19-2).² Most injuries in the private sector in 2015 occurred in the education and health services sector, and the highest injury rates were in the agriculture, forestry, fishing, and hunting sector.² The injury rate for workers in state and local governments exceeded that in all private-industry sectors combined. The occupational injury rate in 2015, averaged across all industries and state and local governments, was 3.1 per 100 full-time equivalent workers. Because the BLS annual survey of employers excludes farms with fewer than 11 employees, the numbers and rates of nonfatal occupational injuries reported for the agriculture, forestry, fishing, and hunting sector should be considered as conservative estimates.

Clinical Presentation and Course of Injuries

In 2014, the most common diagnoses of workers treated for occupational injuries in emergency

departments were as follows: sprains and strains (22%); lacerations, punctures, amputations, and avulsions (19%); contusions, abrasions, and hematomas (14%); dislocations and fractures (7%); and burns (3%).⁴ Most sprains and strains (54%) were to the trunk area (shoulder, back, chest, or abdomen), followed by the lower extremities (legs, feet, and toes, 25%). About 77% of the lacerations, punctures, amputations, and avulsions were to the upper extremities (arms, hands, or fingers). An estimated 4% of occupational injuries resulted in hospital admission.⁴ The most common event resulting in hospitalization was a fall (21%), and the most common diagnosis was fracture (27%).⁴

Of the estimated 1.2 million injuries and illnesses with lost workdays in 2015, the median time away from work was 8 days. Median time away from work was highest for fractures (31 days), carpal tunnel syndrome (28 days), and multiple traumatic injuries with fractures (31 days).¹³

PREVENTION OF INJURIES

Prevention through Design

One of the best ways to prevent occupational injuries is to “design out” hazards and risks early in the design or redesign process, commonly referred to as *prevention through design*. This approach seeks to eliminate or reduce occupational hazards and risks in work facilities, equipment, machinery, tools, and work processes. While prevention through design is not a new concept, in 2007, the National Institute for Occupational Safety and Health (NIOSH) initiated a national prevention through design initiative “to foster designing out occupational hazards in equipment, structures, materials, and processes that affect workers.”¹⁸ Through partnerships with external stakeholders, the national NIOSH plan includes specific goals in research, education, practice, policy, and small business “to more effectively protect workers from injury and disease.”¹⁸ In 2011, the consensus standard Z590-3, *Prevention through Design: Guidelines for Addressing Hazards and Risks in Design and Redesign Processes*, was released.¹⁹ This standard complements several provisions of ANSI Z10

*Occupational Health and Safety Management Systems*²⁰ aimed at preventing workplace serious injuries and fatalities. Case 2 illustrates a situation in which an engulfment hazard could have been reduced or eliminated by application of prevention through design.

CASE 2

A 36-year-old male Hispanic laborer died after becoming engulfed in sawdust inside a sawmill storage silo. The flat-bottomed silo used a three-armed rotating sweep auger mechanism to funnel stored sawdust through an opening in the silo floor to a transfer auger, which transported the sawdust to another part of the sawmill for use in generating electricity for the mill. Due to the flat-bottom design of the silo, the sweep auger was prone to frequent clogs, requiring workers to manually unclog the system with rakes and poles. The worker had entered the silo to manually clear a clog; soon afterward, sawdust that had accumulated on the sides of the silo collapsed, completely engulfing him.

Although several factors contributed to this worker's death, NIOSH investigators recommended retrofitting the silo with a mechanical leveling/raking device that would improve the flow of loose materials, such as sawdust, to minimize or eliminate the need for workers to enter into this confined space.²¹

The Hierarchical Approach to Occupational Injury Control

In addition to the concept of prevention through design, several models for occupational injury control have evolved over the years. Some of these models categorize worker protection strategies based on a hierarchy of controls: (a) hazard elimination, (b) hazard substitution, (c) engineering controls, (d) warning systems, (e) administrative controls, and (f) PPE (Table 19-3).²²

William Haddon Jr. proposed 10 basic strategies for injury prevention that have several similarities to the hierarchical approach, such as hazard elimination, hazard reduction, and use of barriers for protection.²³ He also introduced

Table 19-3. Hierarchy of Controls

A	Elimination—Eliminate or reduce hazards through system design and redesign
B	Substitution—Substitute less hazardous methods, materials, or processes for more hazardous ones
C	Engineering Controls—Prevent access to hazards
D	Warnings—Alert workers to hazards (Warnings are often considered an administrative control because they require an active response from workers in order to be effective.)
E	Administrative Controls—Change the way people work
F	PPE—Protect workers from hazards with personal protective equipment

Source: Manuele FA. *Advanced safety management: Focusing on Z10 and serious injury prevention* (2nd ed.). Hoboken, NJ: John Wiley & Sons, 2014.

the concept that injuries were caused by a chain of multifactorial events, each of which provided opportunities for intervention. Epidemiology, safety engineering, biomechanics, ergonomics, psychology, safety management, and other types of expertise comprise a multidisciplinary approach that is useful for identifying injury risk factors and developing control strategies.

Elimination and Substitution

The most effective approach is to eliminate a hazard completely—the top tier of the hierarchy of controls and a tenet of prevention through design. One example is locating pumps, agitators, and gauges outside of confined spaces so that worker entry is not required for maintenance, repair, or monitoring. Substitution replaces hazardous materials, processes, or equipment with those that are less hazardous, such as using materials handling equipment in place of manual materials handling.

Engineering Controls

If a hazard cannot be eliminated completely through design or an appropriate substitution, then the next strategy should be to implement engineering controls that prevent or reduce hazards through the application of safeguards. For example, many types of industrial equipment require power transmission units that include belts, pulleys, gears, shafts, and other mechanisms necessary for the equipment to function. Workers can be exposed to serious, or

even fatal, injury hazards if they contact these rotating or moving components. A fixed barrier guard that completely encloses the power transmission unit is an engineering control that protects workers from being caught in or struck by hazards by preventing worker contact with any moving parts. As long as the guard remains in place, the worker is protected from injury. Another engineering control is an optical sensor, also called a light curtain, used to protect the worker from injury when operating a mechanical power press (Figure 19-3). The optical sensor is integrated into the press control mechanism so that if any part of the worker's body breaks the plane of light in front of the hazardous point of operation, the downward motion of the press ram cannot be initiated or, if motion has begun, the press ram is automatically disengaged.

Many engineering controls are interlocked to ensure that they cannot be removed without disabling the machine or equipment. An interlock is a device that is integrated into the control mechanism of a machine or work process to prevent the work cycle from being initiated until the interlock is closed, signaling the equipment that the work cycle can be initiated. One example is a skid-steer loader with interlocked driver controls

that require the operator be properly positioned inside the equipment, with the seat belt fastened, before the equipment can be started and the bucket raised. Interlocks, which are usually electrical or mechanical controls, need to be designed so that they are not easily bypassed or disabled.

Elimination, substitution, and engineering controls are often referred to as *passive controls* since they typically do not require worker involvement to be protective. However, passive controls should be designed so that they do not adversely interfere with work processes or introduce additional hazards. Although passive controls are generally more effective prevention strategies than those that require worker involvement, it is not possible to implement them for all potentially hazardous work situations.

Warnings and Other Administrative Controls

Administrative controls are management-directed work practices or procedures that, when implemented, will reduce exposure to hazards and the risk of injury. They are sometimes referred to as *active controls* because they require worker involvement to be effective. Warning systems, safe work practices and procedures, and worker training are examples of administrative controls. Workers must react to warnings, such as back-up alarms and smoke detectors, follow prescribed safe work practices and procedures and apply the training they have received in order to prevent injuries. Other examples of administrative controls include housekeeping procedures requiring that spills or debris be cleaned up quickly to reduce the potential for a slip, trip, or fall injury (Figure 19-4) and implementation of hazardous energy-control policies, such as for lockout/tagout procedures, for workers performing maintenance on machines. (Figure 19-5). These procedures should be written and consistently implemented, and workers should be trained in their use.²⁴

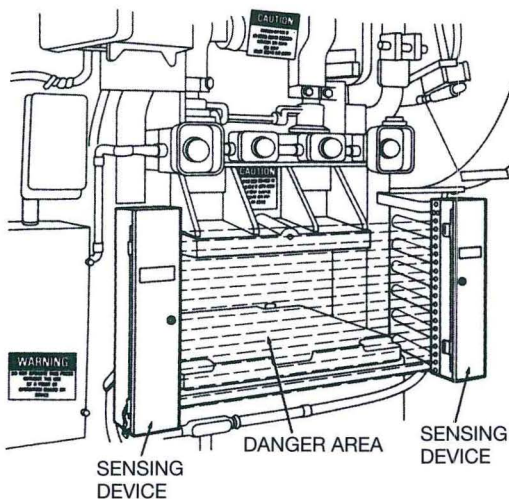


Figure 19-3. Photoelectric (optical) sensor installed on a mechanical power press to protect the point of operation. (Source: Occupational Safety and Health Administration. Concepts and techniques of machine safeguarding. Washington, DC: OSHA, 1980.)

Personal Protective Equipment

If hazardous injury exposures cannot be prevented through elimination, substitution, engineering, or administrative controls, then PPE provides the last line of defense for worker protection. Personal protective equipment consists of devices worn by workers to reduce (a) the risk

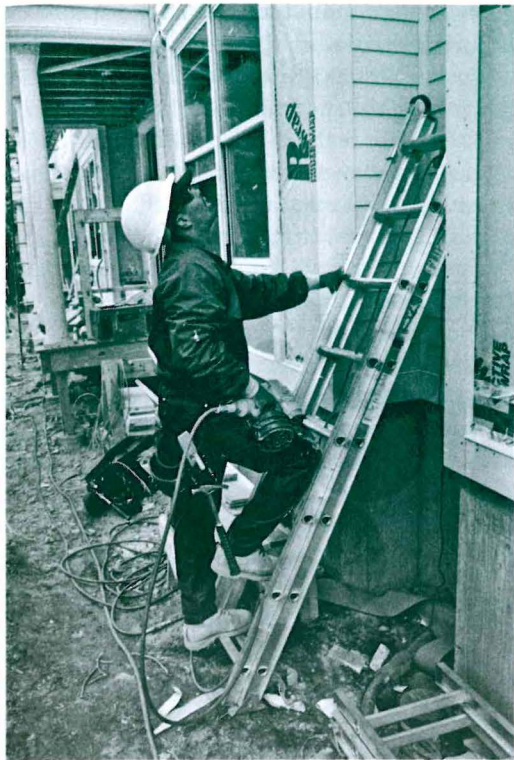


Figure 19-4. Example of poor housekeeping on a construction site. Loose bricks, lumber, and other debris create a potential tripping hazard for workers. (Photograph by Earl Dotter.)

that exposure to a hazard will injure the worker or (b) the severity of an injury if one does occur. Although the hazard still exists, the potential for worker injury is mitigated by using PPE. The use of PPE in many work environments is essential for worker protection. However, PPE is usually viewed as the least effective approach for injury prevention and is the lowest tier on the hierarchy of controls. Active decision-making by management to identify required PPE, worker consultation to identify the most comfortable or user-friendly PPE, policies that encourage appropriate use, and follow-up evaluation to determine effectiveness are necessary to achieve the intended protection for which the PPE is designed. Examples of PPE for reducing worker injuries include protective hard hats, eyewear and face shields, steel-toed safety shoes, fall restraint devices, and personal flotation devices (Figure 19-6). When worn properly and as necessary, PPE can prevent, or at least reduce the severity of, traumatic injuries.



Figure 19-5. Lockout hasp on an electrical control panel that provides a method for applying a lock (lockout) to the panel during maintenance or repair to ensure that the equipment is not energized until the work has been completed. The control panel should also be tagged (tagout) with a label indicating that work is being performed. Workers should be provided with individually keyed locks, and only the worker who applied the lock should remove it. (Source: Occupational Safety and Health Administration. Concepts and techniques of machine safeguarding. Washington, DC: OSHA, 1980.)

Fall-restraint devices, such as lanyards and body harnesses, do not prevent workers from falling, but protect them from suffering more serious injuries or fatalities due to falls from elevations (Figures 19-7A and 19-7B).

Combined Application of Controls

A comprehensive approach to worker injury prevention inevitably includes all tiers of the control hierarchy to achieve maximal worker protection. In most work environments, a combination of elimination, substitution, engineering controls, warning systems, administrative controls, and PPE will often be required to have a complete and effective injury prevention program. The following examples illustrate how the combined



Figure 19-6. Example of worker using multiple forms of personal protective equipment, including hard hat, face shield, hearing protection, work gloves, knee pads, and work boots. (Photo Courtesy of Mine Safety Appliance Company.)

application of controls can be used to achieve an optimal level of worker protection.

Tractors equipped with a rollover protective structure (ROPS), an engineering control, significantly reduce the risk that the operator will be injured in a rollover event (Figure 19-8). However, more effective protection can be achieved if a seat belt, an administrative control, is worn to keep the operator within the protective envelope of the rollover protective structure. Another example is the increased protection afforded by the combined use of seat belts, mandated in company safety policies and programs, in motor vehicles that are also equipped with air bags and advanced safety features, such as traction-stability control systems and forward-collision avoidance systems with automatic braking.

Training

Training refers to methods that help individuals acquire knowledge (safety information on potential workplace hazards), change attitudes (perceptions and beliefs regarding safety), and practice safe work behaviors (organizational,

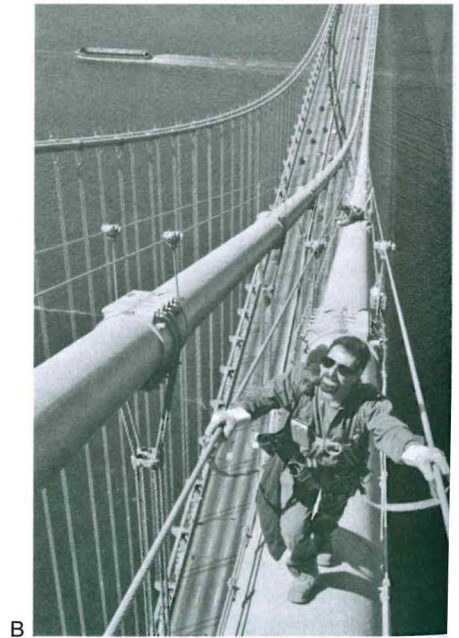
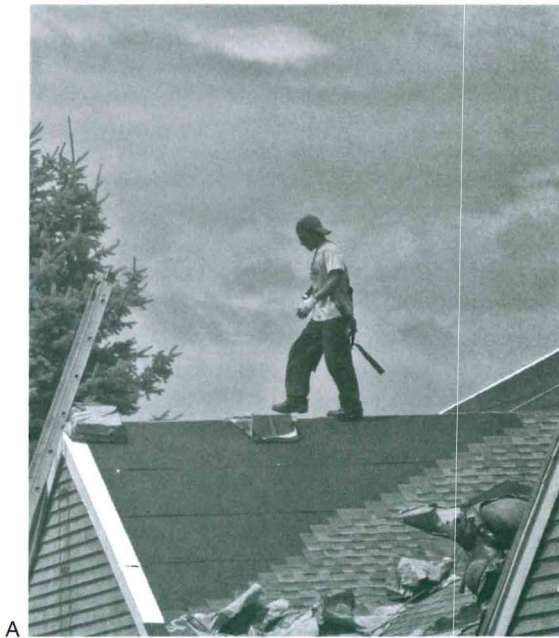


Figure 19-7. (A) Roof worker without fall protection. (Photograph by Marvin Lewiton.) (B) Bridge inspector with ropes that provide fall protection. (Photograph by Earl Dotter.)

management, or worker performance). Despite inadequate data on the direct relationship between training and injury, evidence suggests a positive impact of training on establishing safe working conditions.²⁵ Training is one of the key factors accounting for differences between companies with low and high injury rates. It is often critically important for developing and implementing effective hazard control measures.^{25,26} Training increases hazard awareness and knowledge, facilitates adoption of safe work practices, and leads to other workplace safety improvements. Training is an administrative control, as workers must properly use training they have received on a consistent basis for it to be effective in preventing injuries.

Effective training programs (a) assess training needs specific to the work task, (b) develop training to address these specific needs, (c) set clear training goals, and (d) evaluate the post-training knowledge and skills and provide feedback to the workers.²⁵ Another important characteristic of a successful program is management commitment to safety and training that is initiated as soon as a worker is hired and continued through periodic retraining and reinforcement.^{25,26}

Unique characteristics of the specific workforce must be considered when developing or implementing safety training programs. Language, literacy, cognition, and cultural issues may diminish the effectiveness of training when programs are not tailored to account for unique or diverse characteristics of the workforce. Workplace safety training appears to be most effective when it includes active learning experiences that stress worksite application and when it is developed and implemented in the context of a broader workplace-based prevention approach.²⁵

Standards

Many standards aim to protect workers from traumatic injury. These standards cover a multitude of hazards and address the work environment, work practices, equipment, PPE, and worker training. The two primary types of worker protection standards consist of (a) mandatory standards, such as those promulgated by OSHA or other regulatory agencies, and (b)

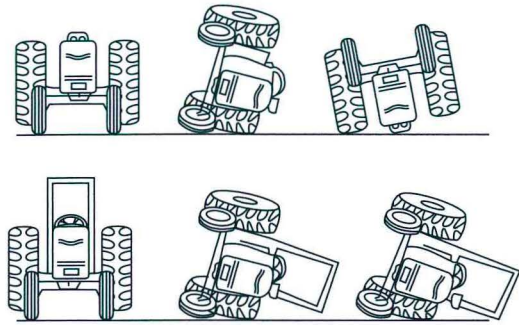


Figure 19-8. The tractors on the lower of the two rows shown above each have a two-post roll-over protective structure (ROPS) frame installed. The ROPS is designed to reduce the risk of injury or death by preventing the tractor from rolling onto and crushing the operator. A properly fastened seat belt greatly improves the chances that the operator will stay within the protective envelope of the ROPS. (Source: National Institute for Occupational Safety and Health. Safe grain and silage handling (DHHS [NIOSH] Publication No. 95-109). Washington, DC: NIOSH, 1995.)

voluntary standards, such as those developed through independent organizations, like the American National Standards Institute, through a consensus process involving various stakeholders in an industry—typically including representatives from labor, management, government, academia, and manufacturers. Numerous specifications, codes, and guidelines for machinery, equipment, tools, and other materials can also assist engineers and designers in developing safer products and systems, many of which have application in the workplace. Examples include the National Electric Code published by the National Fire Protection Association as well as numerous consensus standards from the American Society of Mechanical Engineers and the American Society for Testing and Materials.

Injury Control: Roles and Responsibilities

Occupational injury prevention is not the sole responsibility of a single person or group. Employers, workers, public health and safety practitioners, researchers, regulators, and policy-makers each share in the responsibility for prevention. A multidisciplinary approach involving interaction among diverse groups is crucial to

developing and implementing effective occupational injury prevention strategies.

Within an organization, active participation by both management and workers is essential to an effective safety program. Employers are responsible for establishing written safety policy, developing a comprehensive safety program, and effectively implementing that program at the workplace. A competent person or committee should be designated with responsibility for overall planning and implementation of company safety policy. This person or committee should have sufficient knowledge concerning safety policy, standards, regulations, and hazard abatement and should actively participate with managers and workers in coordinating and overseeing the safety program.

An effective safety program will strive to identify hazards through job safety analysis or other methods of systems safety analysis and will eliminate or control identified hazards through the various approaches previously described. Workers, managers, and safety specialists should work together to analyze the job and potential hazards and to recommend changes or controls to abate them to avoid an injury event. Table 19-4 includes injury hazards with examples from each of the three main categories of hazard control strategies: passive (elimination/substitution/engineering controls), active (warning systems and administrative controls), and PPE. The most comprehensive safety programs will typically require strategies from all six tiers from the hierarchy of controls. In industries or jobs where the work environment is not constant, site hazard assessments should be performed prior to beginning work in any new or changing environment. Occupations such as farming, logging, construction, oil and gas extraction, and mining are characterized by frequently changing work sites and require a site hazard assessment prior to commencing work in any new or changed environment. This requirement is particularly important in industries such as construction and utility maintenance, where worksites change not only from job to job but also from day to day—even hour to hour—with constant potential for new hazards.

Employers are also responsible for ensuring proper maintenance of vehicles, equipment, and machinery and their safety features, such as machine guarding, interlocks, warning systems, and barriers. Where job hazards cannot be

eliminated or controlled, employers are responsible for providing appropriate PPE, such as fall arrest systems, respirators, hearing protectors, hard hats, or protective eyewear.

Employers must also ensure that workers receive appropriate training in minimizing their risk—including training on safety policy and practice, hazard recognition and control technologies, and the appropriate use of PPE. Enforcement of safety policies is also a critical employer responsibility. The demonstrated commitment of management to safety is a major factor in successful workplace safety programs.²⁷⁻²⁹ Employers are more likely to have successful safety programs when they demonstrate concern by having top managers personally involved in safety activities and routinely involve workers in decision-making about safety matters. As part of a comprehensive safety program, employers should require systematic reporting and tracking of occupational injuries and “near-miss” events as well as assessment of this information for corrective action to prevent similar occurrences.

In the case of multiple employers, such as temporary staffing agencies providing workers to other employers, it is critically important that responsibilities for worker safety be clearly delineated in contracts. Both the temporary staffing agency and the worksite employer should play an active role in worker safety.³⁰ This may include the temporary staffing agency conducting site visits and reviewing safety records before entering into contractual arrangements with other employers and ensuring that the tasks, job safety analyses, and training and supervision that will be provided to employees are documented. Worksite employers will have responsibility for task-specific safety training, supervision, and the provision of a safe work environment.

Workers also play a vital role in workplace safety. Their participation is essential. Workers share in the responsibility for complying with safe work practices and policies, maintaining a safe work area, and using appropriate PPE when required by their employer. Workers should also participate in company-sponsored training. They should report injuries, near-miss events, and unsafe conditions for corrective action. As the experts in their jobs, workers should be involved in systems safety analysis and development of safe solutions. Workers’ input into recommended design or modification of safety

Table 19-4. Injury Hazards and Illustrative Control Strategies by Category

Injury Hazard	Passive Controls: Elimination/Substitution/Engineering Controls	Warnings and Other Administrative Controls	Personal Protective Equipment
Motor vehicle crashes	Ensure all vehicles are equipped with air bags and advanced safety features, such as forward collision avoidance systems with automatic braking and traction stability control	Implement a mandatory seat belt policy; purchase vehicles with blind-spot monitoring and lane-departure warning systems	Provide helmets and eye protection for workers whose jobs require operating motorcycles or bicycles
Assaults	Install bullet-resistant barriers or enclosures in retail settings	Train workers in nonviolent response when confronted with volatile situations	Provide body armor for public safety workers
Falls from elevation	Install grids or screens over skylight fixtures that meet OSHA standards for protection from falls through skylights	Train workers to set up extension ladders at the optimal inclination angle of 75° using the NIOSH ladder safety smart phone app*	Provide personal fall-arrest systems during work at elevations
Falls to same level	Redirect downspouts away from walkways with high pedestrian traffic	Implement a policy encouraging workers to clean up or report floor spills promptly	Provide or require workers to wear shoes with slip-resistant soles
Caught in	Ensure that controls on skid-steer loaders are interlocked and require operators to be properly positioned with seat belts fastened before the vehicle can be started and the bucket raised	Develop standard procedures for safely clearing material jams on machinery and equipment	Ensure long hair is tied back or covered when working around machinery with rotating or moving components
Struck by	Install fencing or other physical barriers around robots or other moving equipment, with access through interlocked gates	Minimize forklift traffic during shift changes to reduce exposure to moving forklifts during times when large numbers of worker pass through an area during a short time period	Provide protective hard hats, eyewear, and shoes
Contact with electrical energy	Install ground fault circuit interrupters in damp or wet locations	Develop and implement a hazardous energy control policy for all maintenance and repair activities	Provide electricians with properly rated dielectric gloves when procedures require work on energized components, such as troubleshooting an electrical panel
Overexertion	Use mechanical lifting devices, such as ceiling mounted cranes, to lift heavy and bulky items	Use job rotation schedules with different physical demands to reduce the frequency of lifting and repetitive motion tasks	Provide workers with nonslip safety gloves during manual materials handling tasks
Confined spaces	Where possible, locate serviceable components, such as pumps, agitators, and gauges outside of confined spaces so that entry is not required for maintenance, repair, or monitoring	Ensure workers test any confined space for flammable, toxic, or oxygen-deficient atmospheres prior to entry; identify and post warning signs outside of all confined spaces	Provide self-contained breathing apparatus or other appropriate air-supplied respirators if entry is required into spaces with flammable, toxic or oxygen-deficient atmospheres

Note. OSHA = Occupational Safety and Health Administration; NIOSH = National Institute for Occupational Safety and Health.

* NIOSH Ladder Safety Mobile Application. Available at: <http://www.cdc.gov/niosh/topics/falls/mobileapp.html>.

controls, processes, or technology and into the development of safe work practices increases the acceptance of positive changes and, thus, the success of safety programs.

An effective workplace safety program that minimizes injuries results from a multidisciplinary effort that actively involves every level of the workforce, from the employer and upper-level

managers to employee representatives and workers. Each must assume some responsibility for safety and must work together interactively to achieve the common goal of preventing injuries.

Researchers provide science-based approaches to workplace injury prevention. The development of injury prevention strategies and technologies, through laboratory studies and field evaluations, yields evidence-based strategies and solutions to existing and emerging hazards. It is important for researchers and industry to work together in partnership throughout the research process to ensure that prevention strategies are relevant and applicable to the workplace, to demonstrate and evaluate prevention effectiveness in actual work settings, and to facilitate the transfer of research results to implementation and practice in the workplace. Injury prevention research results will only be effective in reducing injuries if they are directly communicated and transferred to employers, trainers, safety practitioners, regulators, and policymakers who can implement research results for prevention action. This research-to-practice process, developing and applying science-based prevention strategies in the workplace, is also a shared responsibility of the multiple entities with vested interest in workplace injury prevention.

Government agencies also play a role in preventing occupational injuries. Federal and state

labor agencies are involved in data collection on occupational deaths and injuries through the BLS, and they serve a regulatory function by establishing standards for safe work practices and enforcing those regulations. Federal OSHA and 28 states and territories authorized by OSHA promulgate and enforce mandatory minimum standards for occupational safety and health in most industry sectors. The Mine Safety and Health Administration collects data and has regulatory responsibilities for miners. Other governmental agencies have prevention responsibilities for segments of the workforce, including agencies within the U.S. Department of Transportation for workers in trucking, transit, railroads, and aviation. Federal and state labor agencies also provide consultative services to employers and education to raise awareness about their standards and injury prevention practices. State health departments are involved in occupational safety at varying levels, including the collection, analysis, and interpretation of unique data not collected by BLS; disseminating occupational injury prevention recommendations using state networks; and ensuring that occupational injury prevention is encompassed within state injury prevention plans. Increasing state health department involvement in occupational safety holds considerable potential for improving worker safety (Box 19-6). (See Chapters 3 and 6.)

Box 19-6. Unique Role for Public Health Agencies in Occupational Safety

In 2008, NIOSH, in conjunction with the Council of State and Territorial Epidemiologists (CSTE), updated the publication *Guidelines for Minimum and Comprehensive State-Based Public Health Activities in Occupational Safety and Health*.¹ This publication highlights the important role of state public health agencies in fostering occupational safety and health, based on the three core functions of public health identified by the Institute of Medicine in 1988: assessment, policy development, and assurance.

Assessment: Assessment involves the regular and systematic collection, analysis, and communication of the public's health, including statistics on health status. There are numerous state-level data sources for assessing occupational injuries that include injuries not captured in the national occupational injury systems

overseen by the BLS. These unique state-level data include hospital discharge data, emergency department data, workers' compensation records, burn center data, and poison control centers' data. CSTE has identified key occupational injury indicators that use existing state-level data to assess and track trends in occupational injuries at the state level, and these have been reported by 27 states to date. In-depth analyses of state-based occupational injury surveillance data have been conducted in several states, leading to state-specific injury prevention efforts, including prevention of burns and injuries among teen workers.

Policy development: Policy development involves the responsibility to develop public health policies based on scientific knowledge. Examples of how state health departments can contribute to sound policy development to improve worker safety include collaborating with stakeholders in establishing statewide

(continued)

Box 19-6. (Continued)

occupational safety objectives, such as the Healthy People 2020 objectives for the nation² to reduce occupational injuries; collaborating with public health partners to encompass the prevention of occupational injuries in broad statewide injury prevention programs and plans (such as those focused on reducing transportation injuries and injuries to adolescents); developing programs and working relationships with partners, such as state labor departments and OSHA, to collectively work toward preventing occupational injuries; and developing program capacity to identify and respond to emerging occupational safety hazards or unique prevention opportunities.

Assurance: Assurance involves making sure that services are available at the state level to achieve agreed-upon goals, such as injury prevention generally, or occupational injury specific goals. State health departments should have sufficient occupational safety expertise and resources to meet their populations' information needs and be able to provide appropriate referrals for technical assistance.

Public health agencies have statutory, regulatory, and philosophical commitments to protect the health of the public, including vulnerable groups who may fall outside the jurisdiction of federal or state regulatory agencies. The NIOSH/CSTE publication noted here provides guidelines on developing state-based public health programs

in occupational safety and health, ranging from minimum activities that can be performed with existing state health department staff and data to more comprehensive approaches that require additional resources. It is intended that these guidelines will be used by state health agencies to develop the capacity for minimum activities in every state and to enhance existing programs. Numerous examples of state-based public health activities in occupational safety and health suggest that state public health agencies have a critical and complementary role to state labor agencies in preventing occupational injuries.

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CONCLUSION

Occupational injuries continue to exert too large a toll on the workforce. While the rate of fatal injuries in the United States has decreased markedly over time, the rate of nonfatal injuries has not been reduced as much. The prevention of workplace injuries requires concerted and consistent efforts from multiple parties using multiple strategies. In addition to the primary stakeholders in the workplace, additional groups can help reduce occupational injuries. These groups include researchers who provide the evidence base for effective prevention strategies and technologies, manufacturers and distributors of industrial equipment and tools that design and promote safety features of equipment, insurers who provide monetary incentives for good safety records and practices, and healthcare providers and public health practitioners who provide their patients and constituents with information on preventing workplace injuries.

AUTHORS' NOTE

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 (NIOSH). Mention of company names or products does not constitute endorsement by NIOSH. In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All web addresses referenced in this document were accessible as of the publication date.

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FURTHER READING

- American National Standards Institute. Safety of Machinery; General Requirements and Risk Assessment Electronic Standard. B11.0-2015. Park Ridge, IL: American Society of Safety Engineers, 2015.
- This standard specifies basic terminology, principles, and a methodology for achieving safety in the design and the use of machinery. It specifies principles of risk assessment and risk reduction to help designers, integrators, and users of machinery in achieving this objective. These principles are based on knowledge and experience of the design, use, incidents, accidents, and risks associated with machinery. Procedures are described for identifying hazards and estimating and evaluating risks during relevant phases of the machine life cycle and for the elimination of hazards or the provision of sufficient risk reduction. Guidance is given regarding the documentation and verification of the risk assessment and risk reduction process.*
- Baron S, Cone J, Souza K (Eds). Special issue: Occupational health disparities. American Journal of Industrial Medicine, May 2014. *This special journal issue includes papers presented at Eliminating Health and Safety Disparities at Work, a 2014 multidisciplinary*

national conference. The issue includes commentaries and research papers addressing disparities by demographics, such as race and ethnicity; employment arrangements, such as temporary workers and day laborers; and illustrative industries, such as the hotel industry.

Haight JM (Ed.). *Safety professionals handbook*, Vol. 1: Management applications and Vol. 2: Technical applications (2nd ed.). Park Ridge, IL: American Society of Safety Engineers, 2012. *This handbook serves as a reference for managers to improve safety, occupational health, or environmental programs addressing safety engineering management, hazard communication and right-to-know, environmental management, safety and health training, workers' compensation, and fleet safety. It also explains regulatory issues, applied science and engineering principles, cost analysis and budgeting, benchmarking and performance criteria, and best practices.*

Manuele FA. *On the practice of safety* (4th ed.) Hoboken, NJ: John Wiley & Sons, 2013. *This textbook addresses a broad range of topics on the practice of safety useful to managers, safety professionals, educators, and students. It includes chapters ranging from defining the practice of safety, the costs of worker injuries and illnesses, incident investigation, system safety, prevention through design, risk management, and measuring safety performance.*

Myers ML. *Occupational safety and health policy*. Washington, DC: American Public Health Association Press, 2015.

This comprehensive book provides information on occupational safety and health policy. It includes information on worker safety and health legislation, such as the Occupational Safety and Health Act and the Mine Safety and Health Act; how these laws have been implemented; and how they are enforced. Information is provided on other legislation and policy that impacts worker safety and health, including workers' compensation and right-to-know and privacy laws.

Occupational Safety and Health Administration. *Concepts and techniques of machine safeguarding*. OSHA 3067. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, 1992 (revised). Available at: https://www.osha.gov/Publications/Mach_SafeGuard/toc.html. Accessed September 14, 2016.

An excellent reference for identifying potential hazards when working with industrial machinery. The publication also provides general principles of machine safeguarding to protect workers from injury.

Wallerstein N, Rubenstein H. *Teaching about job hazards: A guide for workers and their health providers*. Washington, DC: American Public Health Association, 1993.

This comprehensive manual provides guidance for health and safety education to workers, including guidance specific to healthcare providers, as well as information for occupational safety and health training resources.

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Seventh Edition

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