

# CHAPTER 13

## HEALTHY WORKPLACES

Jonathan A. Bach, Paul A. Schulte, L. Casey Chosewood,  
and Gregory R. Wagner

### KEY POINTS

- The design of the work environment contains opportunities to support and promote safety, health, and well-being while contributing to environmental, social, and economic sustainability.
- Work becomes safer through interventions such as reduced use of hazardous chemicals; ergonomically designed tools and workstations; built-in protection from hazards such as falls from heights; tools and equipment designed to be quieter; more effective controls of dust and vapor exposures; and other health-supportive designs, policies, and practices that mitigate risk and reduce stress.
- Improving indoor environmental quality through engineering involving heating and cooling systems, natural daylighting, and outdoor views has beneficial psychological effects on occupants.
- Workplace interventions such as layouts that encourage walking, attractive and well-placed stairwells that encourage use, availability of healthier food options, and an active transportation infrastructure can increase worker health on and off the job and promote sustainability.
- Compliance with occupational safety and health regulations and use of consensus standards, sustainability reporting systems, and third-party building rating systems provide avenues for worker health and safety and environmental performance.

### INTRODUCTION

In 2017, a nineteen-year-old “gig economy” bicycle food delivery worker in Massachusetts was killed when he was hit by a truck driver who did not see the cyclist in the truck’s blind spot. There was no bicycle lane, and the worker was not wearing protective gear.<sup>1</sup>

In 2017, a twenty-year-old drywall installer in Michigan fell thirty feet to his death when an unguarded skylight he fell onto gave way.<sup>2</sup>

In 2020, a forty-four-year-old farmworker in Kentucky was killed when he entered a grain bin to try to dislodge jammed corn. The corn collapsed on him and smothered him.<sup>3</sup>

In 2015, a sixty-year-old farm caretaker in Michigan was pulling a downed tree when his tractor overturned to the rear and killed him—his tractor did not have a ROPS (Roll Over Protection Structure).<sup>4</sup>

In 2017, a sixty-one-year-old truck driver in Washington State backed her trailer up to a loading dock, walked into the trailer to clean the floor, and was crushed to death when a noisy forklift started loading the truck with a large load that obscured her presence.<sup>5</sup>

In 2018, a sixty-seven-year-old municipal crossing guard in Massachusetts was fatally injured when she was struck by a passing motor vehicle while assisting students in crossing the roadway.<sup>6</sup>

In 2019, a seventy-two-year-old grocery worker in California stocking shelves alone

died when he fell from a straight ladder that was wet with rain.<sup>7</sup>

From 2001 to 2007, employees in a large state office building in Connecticut experienced an increased prevalence of asthma, hypersensitivity pneumonitis, and various respiratory symptoms. The building design allowed water intrusion that repeatedly soaked building materials and led to mold. Despite millions of dollars spent on building renovations to try to solve the problem, the state eventually vacated the building and sold it at a loss.<sup>8-10</sup>

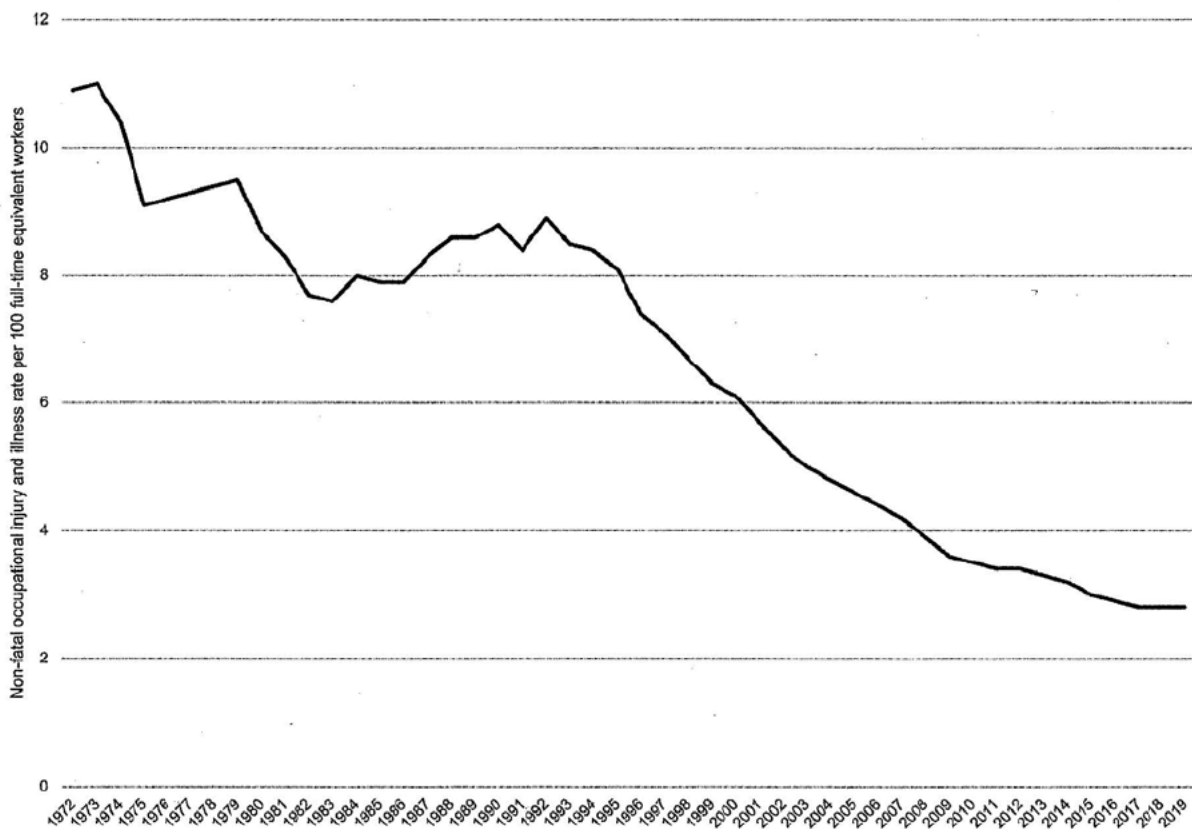
In 2020 and 2021, workers in public-facing jobs such as grocery stores and public transit encountered risks of airborne disease transmission during the COVID-19 pandemic.<sup>11</sup>

In all these examples, workers could have been protected by improvements in the design of the workplace environment or in the policies that guide workplace activities.

As part of the Occupational Safety and Health Act of 1970, the US Department of Labor Bureau of Labor Statistics gathers and reports worker injury and illness data.<sup>12</sup> Efforts to reduce non-fatal injuries and illnesses led to a 75 percent reduction in the rate of injuries and illnesses from 1972 through 2019 (figure 13.1). Although the *rate* has greatly decreased, there were still at least 2.8 million workers in the United States who became ill or injured due to work in 2019.

Fatalities from work injuries are less common than nonfatal injuries and illnesses. In the United States, deaths from work injuries decreased 33 percent from 5.2 in 1992 to 3.5 in 2019 per 100,000 full-time equivalent workers<sup>13</sup> (figure 13.2). Despite improvements, at least 5,333 US workers died from workplace injuries in 2019.

Fatalities and nonfatal injuries and illnesses often result from different circumstances<sup>14</sup>



**Figure 13.1.** Nonfatal occupational injury and illness rate per 100 full-time equivalent workers, private industry, United States, 1972–2019.

Source: Adapted from Jeff Brown, “Nearly 50 years of occupational safety and health data.” *Beyond the Numbers: Workplace Injuries* (US Bureau of Labor Statistics). July 2020;9(9). <https://www.bls.gov/opub/btn/volume-9/nearly-50-years-of-occupational-safety-and-health-data.htm>



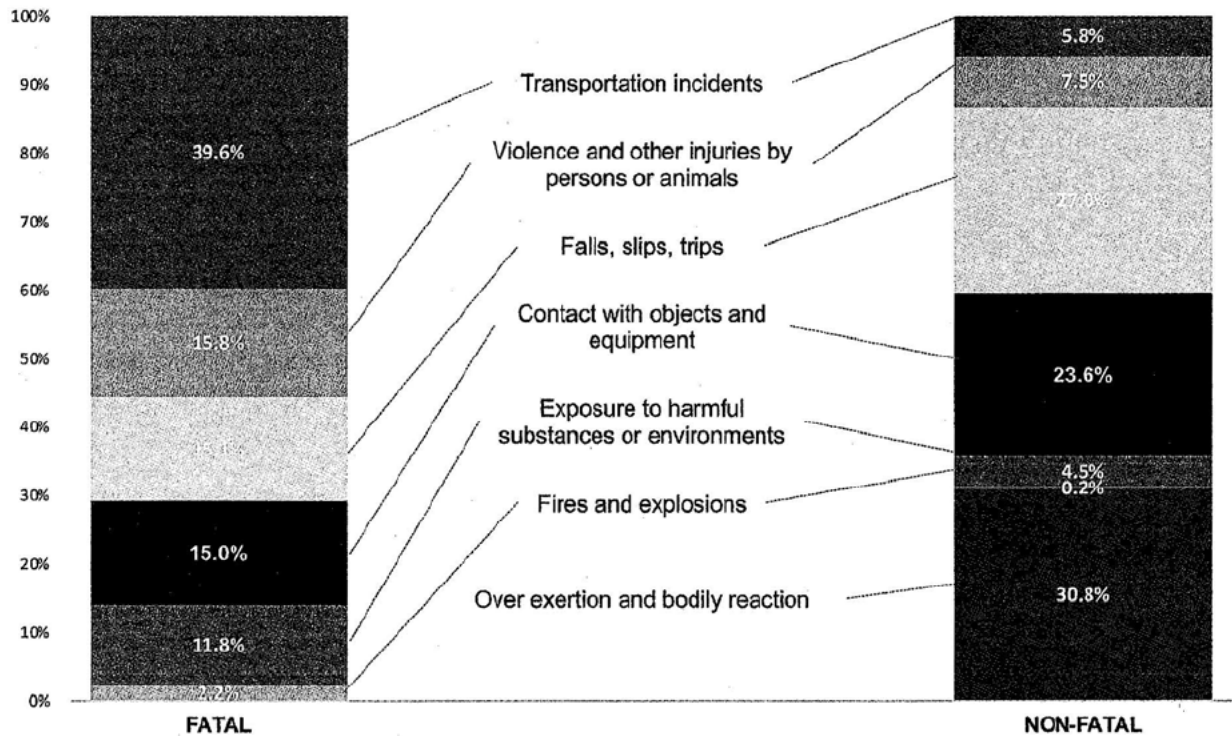
**Figure 13.2.** Fatal work injury rates per 100,000 full-time equivalent workers, United States, 1992–2019. Sources: Data from US Bureau of Labor Statistics, Census of Fatal Occupational Injuries. 1994 through 2019 rates: News Releases, “Census of fatal occupational injuries,” with 1994 through 1999 rates calculated from total fatalities and total employment (rate per 100,000 = 100,000 × fatalities/employment). 1993 rate: Calculated from 1993 fatalities shown in the 1994 news release, plus employment shown on page 20 of *The changing character of fatal work injuries* (*Monthly Labor Review*, October 1994), Guy Toscano and Janice Windau. 1992 rate: A relative risk analysis of workplace fatalities (*Compensation and Working Conditions*, January 1995), John Ruser.

(figure 13.3). For example, although transportation causes the most fatal injuries, overexertion (such as strains and overuse syndrome) and bodily reactions (such as sprains) cause the most nonfatal injuries. Such data help focus strategies for improved prevention.

Many work-related deaths, injuries, and illnesses can be prevented by better design or by redesign of workplaces and how work is organized and performed. This chapter describes a **design safety review** process to evaluate, reduce, or remove hazards proactively. Since 1994, the United Kingdom has required, by law, a similar process on construction projects, resulting in substantial improvements.<sup>15</sup> The United States and most other nations have no such legal requirement. The design safety review process appears to make a difference: in 2019, the rate of construction fatalities in the United Kingdom was one-sixth that of the United States (1.6 versus 9.7 fatalities per 100,000 full-time equivalent workers, respectively).<sup>16,17</sup>

## OCCUPATIONAL HEALTH AND SAFETY

Organized efforts to require safer work often do not gain wide acceptance until major tragedies such as mining collapses, deadly fires, elevator crashes, or industrial explosions occur. One notable case was the 1911 Triangle Shirtwaist Factory incident in New York City, where 146 workers, mostly young women, died in a fire because the factory had locked the exits.<sup>18</sup> As a result, labor organizations were formed that made great strides in improving work safety, with laws and regulations following. Subsequently, standards relevant to worker safety, health, and well-being were developed, such as wage and hour standards, limitations on child labor, and controlled use of toxic substances such as pesticides in agriculture. Mining disasters along with union activism and public pressure contributed to both the Coal Mine Health and Safety Act of 1969 and Mine Safety and Health Act of 1977.<sup>19</sup> A major advance in the United States was the Occupational Safety and Health Act of 1970. The **Occupational Safety and Health Adminis-**



**Figure 13.3.** Distribution of fatal work injuries and nonfatal work injuries and illnesses by major event category, 2018.

Source: Adapted from Jeff Brown, "Nearly 50 years of occupational safety and health data," *Beyond the Numbers: Workplace Injuries* (US Bureau of Labor Statistics). July 2020;9(9). <https://www.bls.gov/opub/btn/volume-9/nearly-50-years-of-occupational-safety-and-health-data.htm>

tration (OSHA) was created shortly thereafter to develop and enforce workplace health and safety standards for general industry and construction. Other countries experienced similar advances, although worker protections in lower- and middle-income countries, with some exceptions, have progressed more slowly.

Efforts to proactively design out hazards in processes and equipment grew to become the field of **system safety**, especially through efforts in the defense, aerospace, and nuclear industries.<sup>20</sup> A streamlined version of system safety, usable for any business, was advanced by the National Safety Council as "Safety through Design," accompanied by a ten-year effort resulting in a textbook by that name.<sup>21</sup> The **National Institute for Occupational Safety and Health (NIOSH)** then continued the effort as **prevention through design**, starting in 2007.<sup>22,23</sup> When a hazard is eliminated by design, worker protection no longer

has to rely on education, perfect compliance with procedures, or flawless use of personal protective equipment. For example, a roof that has railings or parapets at the edge does not require the error-prone use of harnesses and ropes and is a recognized way to eliminate a hazard going back millennia.<sup>24</sup>

Increasing worker involvement in identifying and controlling hazards, followed by management action that makes the work safer and healthier, is a positive trend. OSHA has encouraged such labor-management collaboration for decades,<sup>25</sup> and it is an essential component of the prevention through design consensus standard, ANSI/ASSP Z590.3.<sup>26</sup>

Designing workplaces, as well as work policies and practices, to benefit the safety, health, and well-being of workers is increasingly recognized as important. For example, working overtime is often associated with poorer perceived general health, increased injury rates,

more illnesses, or increased mortality.<sup>27</sup> Long hours of work may also increase exposures to chemical and physical hazards in the workplace, and night shifts may expose workers to heightened risk of violence.<sup>28,29</sup> Aging of the workforce also poses new challenges as almost one-fourth of US workers now plan to work until age seventy or more.<sup>30,31</sup> The risks of work are also changing, such as work adjacent to robots and intensification of work due to efficiency in automation. The built environment of the workplace needs to address these newer hazards along with more traditional concerns. The workplace may also be a useful setting for health promotion efforts to maintain worker health. This chapter provides an overview of the elements to consider when designing or modifying a workplace to both protect and promote the health, safety, and well-being of all individuals in its environment.

#### TYPES OF HAZARDS AND CONTROLS

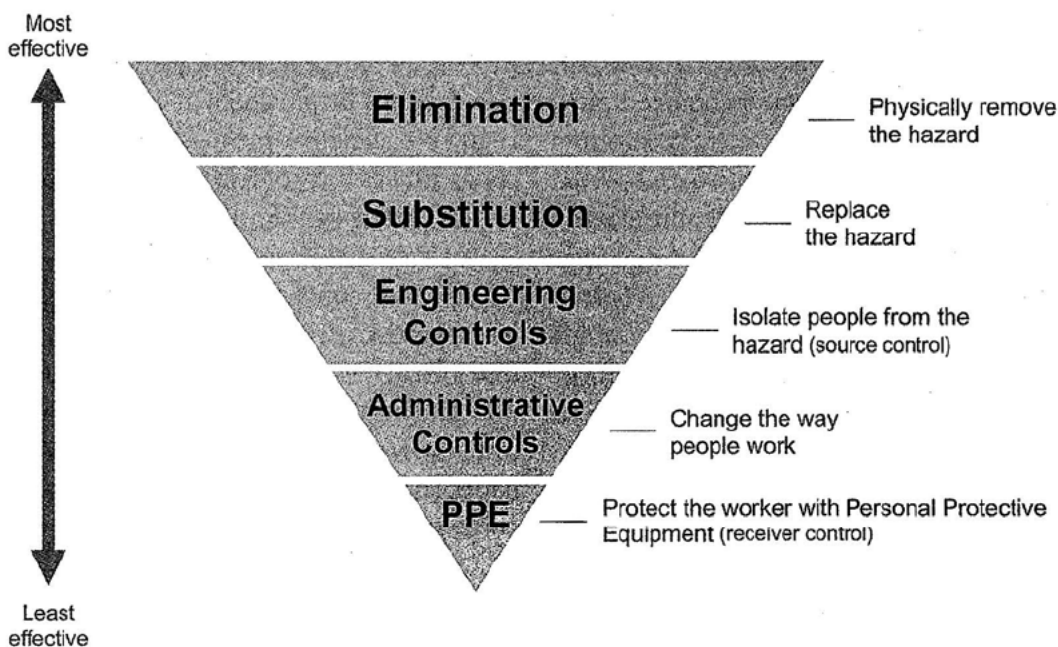
Although the term *safety* is often used to refer to any workplace hazard, organizations large enough to have dedicated occupational safety

and health professionals often assign responsibility for *injury*-causing hazards (typically obvious and sudden) to the “safety” professionals and *illness*-causing hazards (often invisible and cumulative) to the “health” (or “industrial hygiene”) professionals. In many organizations, they are combined into Occupational Safety and Health (OSH) or Environmental, Health, and Safety offices. In small organizations, one person may be responsible for all these responsibilities, and that may not even be their main job.

Hazards may be categorized by type: chemical, biological, physical, safety, ergonomic, or psychosocial. By considering the elements in the **hierarchy of controls** in figure 13.4,<sup>32</sup> strategies to control hazards can be identified for each category (table 13.1) This hierarchy provides a useful approach for reducing occupational hazards and is discussed further in a subsequent section.

#### Continuous Improvement

Central tasks of occupational safety and health professionals are to identify hazards, assess



**Figure 13.4.** Hierarchy of controls for workplace hazards.

Source: Adapted from National Institute for Occupational Safety and Health, US CDC 2020. <https://www.cdc.gov/niosh/topics/hierarchy/default.html>. Reference to specific commercial products, manufacturers, companies, or trademarks does not constitute its endorsement or recommendation by the U.S. Government, Department of Health and Human Services, or Centers for Disease Control and Prevention.

**Table 13.1.** Types of occupational hazards with examples of hazards and control strategies.

Hazard Types	Hazard Examples	Control Strategies
<b>Chemical (substance contact)</b>	<p>Solids, liquids, or gases that can damage or be absorbed through skin or eyes, be inhaled to displace oxygen, damage lungs; or be absorbed into body systems</p> <p>Cleaners, solvents, dusts, welding fumes</p>	<p><b>Eliminate:</b> Redesign chemical processes and formulations to eliminate some or all chemicals. Maintain smoke-free workplaces.</p> <p><b>Substitute:</b> Less-toxic chemicals, water, mechanical cleaning</p> <p><b>Source control:</b> Enclosed mixing or reacting areas, local ventilation near the chemical source</p> <p><b>Administrative:</b> Procedures, training, signs</p> <p><b>Receiver control:</b> Personal protective equipment (PPE) such as gloves, respirators, face shields, clothing</p>
<b>Biological (living things contact)</b>	<p>Poor sanitation, contagious disease, mold growth in warm and moist environments, work with bacteria or viruses, medical waste, work with sewage, work with animals, insects, plants (and their venom, poisons, or waste toxins, which are also "chemical" hazards)</p>	<p><b>Eliminate:</b> Work at home when ill, vaccinations</p> <p><b>Substitute:</b> Smaller or less-hazardous lab animals</p> <p><b>Source control:</b> Enclosures, shields/barriers, restraints, ventilation, cloth mask for sneezing/coughing, ultraviolet germicidal irradiation (UVGI) for surfaces, building design and maintenance to avoid water intrusion</p> <p><b>Administrative:</b> Training, sanitation, access control, adequate paid sick leave</p> <p><b>Receiver control:</b> PPE such as gloves, face masks, face shields. General ventilation dilution, filtering, and sterilizing (UVGI lighting in air ducts or across the upper room)</p>
<b>Physical (energy transfer)</b>	<p>Noise; temperature; poor lighting; sunlight; lasers; ultraviolet light; nonionizing radiation (radio, radar); ionizing radiation (x-rays, radioactive materials)</p>	<p><b>Eliminate:</b> Buy quiet tools, move operator controls to safe area, change process to eliminate hazard</p> <p><b>Substitute:</b> Better lighting, quieter tools</p> <p><b>Source control:</b> Shielding, insulating, interlocks that turn off UVGI lights in ducts when opened for maintenance, UV blocking glass in vehicle cabs, shielding for ionizing radiation</p> <p><b>Administrative:</b> Training, procedures, warning signs, alarms, vacating rooms before portable UVGI light use</p> <p><b>Receiver control:</b> PPE such as warm or cool clothing, sunscreen, glasses, and head covering; hearing protection</p>
<b>Safety (forceful contact)</b>	<p>Slips, trips, falls, cuts, crushes, crashes, explosions, electrical shocks, fires</p> <p><i>Safety hazards are also "physical" hazards (e.g., electrical energy, thermal energy, and kinetic energy from gravity and moving objects)</i></p>	<p><b>Eliminate:</b> Stay at ground level (build modular or prefabricated parts at ground level, to be lifted into place when complete), nonflammable fluids or materials</p> <p><b>Substitute:</b> Slower equipment speeds</p> <p><b>Source control:</b> Nonslip surface, drainage, shields and guard for power tools, explosion-proof electrical fixtures, more electrical outlets to eliminate extension cord use</p> <p><b>Administrative:</b> Training and inspections in housekeeping, procedures, warning signs; prohibit work on live circuits</p> <p><b>Receiver control:</b> PPE such as slip-resistant footwear, reflective vests, hard hats</p>

Table 13.1. Continued

Hazard Types	Hazard Examples	Control Strategies
<b>Ergonomic, Human Factors (body stress, cognitive clarity)</b>	Body mechanics, such as reach, force, leverage, repetition, awkward positions; user interface designs (confusing, provoking errors; clear, concise)	<p><b>Eliminate:</b> Use robots to do the most strenuous tasks, automate part of a process to eliminate some worker tasks</p> <p><b>Substitute:</b> Use smaller, lighter parts or product containers, replace confusing labeling or controls with logical, clear ones, tools with more natural grip angles to allow straighter joints</p> <p><b>Source control:</b> Adjustable workstations to position work for each person's most comfortable use, carts with springs that rise higher as product is removed</p> <p><b>Administrative:</b> Training (controls, lifting), warning signs</p> <p><b>Receiver control:</b> PPE such as shock-absorbing gloves, shoes, floor mats, exoskeletons to shift loading to lower body</p>
<b>Work Organization, Psychosocial (harmful stresses)</b>	Work duration, intensity, repetitiveness, environment; work shift, sleep; toxic leadership, criticism, inadequate training, workplace violence	<p><b>Eliminate:</b> Strictly enforce antibullying policies and address violence risks; address toxic leadership</p> <p><b>Substitute:</b> Enhance workplace (light, air, space, clutter, noise, view, proximity to other workers), encourage feedback with fact-finding, not fault-finding, and correct problems found</p> <p><b>Source control:</b> Increase use of collaborative work teams</p> <p><b>Administrative:</b> Use predictable scheduling sensitive to circadian rhythms. Training (deescalation, communication, workplace etiquette, praise in public/criticize in private)</p> <p><b>Receiver control:</b> Provide employee support, nonpunitive or anonymous reporting channels</p>

risks, and evaluate alternatives. These tasks underlie the most complex system safety efforts in the nuclear, aerospace, and defense industries and the *process safety* efforts in the chemical industry.<sup>33</sup> These principles are also basic to standards for Occupational Health and Safety Management Systems such as the ANSI/ASSP Z10 or the international ISO 45001.<sup>34,35</sup> To advance worker health and safety, it is useful to summarize a simplified *process* from the prevention through design consensus standard.<sup>26</sup>

#### *The Priority Is Prevention*

The principles of prevention through design state that preventing occupational injuries and illnesses is best accomplished by eliminating hazards during design, redesign, and

operations (see figure 13.4). If hazards cannot be eliminated, consider substituting less-hazardous materials, processes, operations, or equipment. Risks to remaining hazards should be minimized using controls at the source (commonly referred to as engineering controls). Administrative controls such as employee training or warnings or receiver (worker) controls such as personal protective equipment are important but less reliable methods for minimizing occupational injury and illness risks and should not be the first or only choice.

#### *The Process Is Design*

With the elimination and reduction of hazards as *priority*, it is valuable to have a management

process to better achieve such improvements. OSHA encourages employee involvement in hazard reduction efforts such as identifying hazards, assessing how severe and how likely the risks might be, and choosing better alternatives.<sup>25</sup> Employees work most closely with the hazards—bringing insights and lessons learned to even the most expert of designers and health and safety professionals. Expression of employee concerns should be encouraged and not penalized. Collaboration with workers can lead to better worker acceptance of solutions since they had a key part in designing them. The tasks of hazard identification, risk assessment, and alternatives assessment are the foundations of system safety, chemical process safety, and the streamlined occupational safety and health process in the ANSI/ASSP Z590.3 Prevention through Design (PtD) standard. When a workgroup forms to carry out this process, the PtD standard refers to it as **design safety review**. This process may be summarized in the following steps:

1. Choose productive players who are experienced in the work tasks, respected by other workers, and can work successfully with management, designers, and health and safety professionals.
2. Come prepared with lessons learned from similar operations.
3. Compile a list of activities and the associated hazards for review.
4. Develop a risk assessment matrix that identifies the likelihood and severity of hazards to help prioritize which hazards to address.
5. Identify and assess alternative strategies to address each high-priority hazard and recommend best strategies.
6. Conduct a review of the workgroup recommendations by the managers responsible for those operations, with acceptance or modification of the recommendations.
7. Make suggested changes with management agreement, train workers, evaluate results, and adjust changes as needed.

## PROMOTING HEALTH AND WELL-BEING

The historical focus on preventing bodily harm in the workplace is being enhanced to include a broader opportunity for workplaces to improve worker health and well-being (box 13.1). For example, the *Global Reporting Initiative* (GRI) publishes a sustainability reporting system used by thousands of businesses of all types in more than one hundred countries. GRI has recently enhanced its 403 Occupational Health and Safety standard to measure success in occupational safety and health management, worker harm prevention, and worker wellness.<sup>36</sup> The GRI standards also shift the focus from *trailing indicators*, such as injury rates, to *leading indicators*, such as training levels, audit frequencies, and average time to implement corrective actions.

## NIOSH HEALTHY WORK DESIGN AND WORKER WELL-BEING PROGRAMS

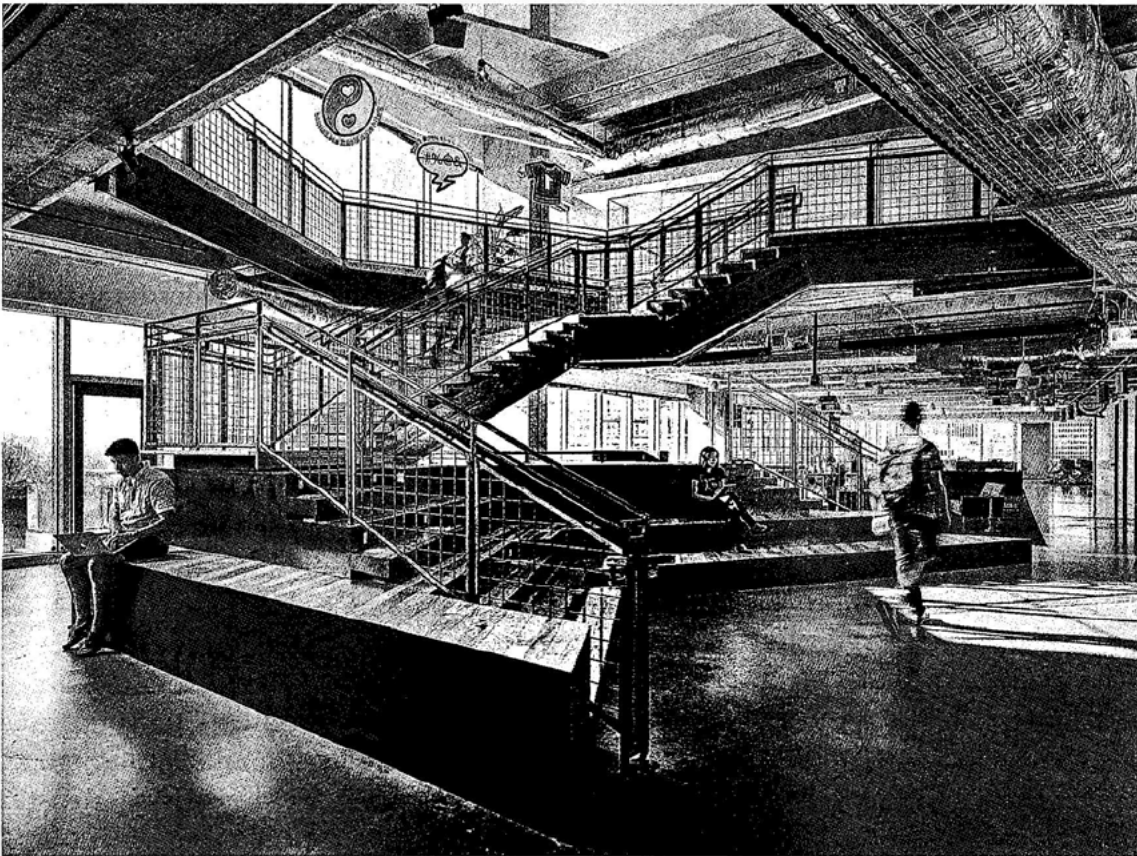
The NIOSH Healthy Work Design and Well-Being initiative seeks to protect and advance worker safety, health, and well-being by improving the design of work, management practices, and the physical and psychosocial work environment.<sup>37</sup> The program establishes research goals for the United States around challenging elements of modern work including examining the impact of worker demographics on employer or organizational practices; improving the safety, health, and well-being of workers with nonstandard work arrangements; addressing the safety and health implications of advancing technology; reducing work organization-related chronic health conditions among workers; decreasing the burden of shift work, long hours of work, and sleep deficiency among workers; improving the well-being of workers through healthier work design and better organizational practices; and promoting a sustainable work-nonwork interface, or work-life fit. NIOSH partners with industry, labor, trade associations, professional organizations, and academia to better understand the ways in which the design of work affects overall health

## BOX 13.1 PROMOTING WORKER WELL-BEING THROUGH DESIGN

Various guidelines have been developed to encourage features that promote worker health, safety, and well-being through design.<sup>a-c</sup> Many of these features are incorporated in the Fitwel and WELL healthy building certification processes (chapter 22). The following are some such features for within and around workplace buildings.

### Within Workplace Buildings

- Clearly defined building entrances to encourage common entry points, clarity, safety, and increased social interaction
- Stairwells that are open and inviting, unlocked, temperature controlled, and prominently located to encourage their use (figure 13.5). Point-of-decision prompts may increase levels of stair use among workers.<sup>d</sup>
- Drinking-water stations, refrigerators, and refrigerated vending machines for perishable fruits and vegetables to encourage improved nutrition<sup>e,f</sup>
- Well-maintained break rooms and bathrooms to encourage breaks and rest as needed
- Lactation rooms where new mothers can pump and store milk to encourage breast-feeding and to assist new mothers in returning to work.<sup>g</sup>
- Ergonomically appropriate workstation design to minimize musculoskeletal strain
- Window treatments and skylights that allow natural light while minimizing glare (especially on computer screens) and comfortable artificial lighting to enhance worker well-being<sup>h</sup>
- Rooftop railings and skylight guards to protect maintenance workers



**Figure 13.5.** Safe and attractive staircases, such as this one in an office building, can promote physical activity and social connections as well as provide flexible working spaces.  
Source: Photo courtesy of Perkins+Will

## BOX 13.1 CONTINUED

### In Areas around Workplace Buildings

- Defined zones for walking, bicycling, and automobiles to increase safety of bicyclists and pedestrians
- Convenient access to public transit to encourage transit use and walking to transit
- Safe and attractive pedestrian paths and trails designed to encourage walking before, during, and after the workday. A worksite walkability audit can assess the safety and attractiveness of the walking routes at a worksite.<sup>h,k</sup>
- Promenades, boardwalks, courtyards, food venues, gardens, and other pedestrian-oriented public spaces to encourage social interaction and increase the livability of office environments.<sup>l,m</sup>
- Indoor and outdoor fitness facilities and places to walk to encourage employees to be physically active<sup>n</sup>
- Bicycle infrastructure, including covered bike racks, lockers, showers, and changing rooms to encourage use of active transportation for commuting and during the workday
- Smoking areas, if any, located away from building entrances and air intake vents.<sup>o</sup>

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and well-being and how it can be improved to enable workers to thrive and contribute productively at work, at home, and in society.

Traditional occupational safety and health protection programs have primarily concentrated on ensuring that work is safe and that workers are protected from the harms that arise from work itself. NIOSH's *Total Worker Health* (TWH) research program builds on this approach through the recognition that work is a social determinant of health.<sup>38</sup> Job-related factors such as wages, hours of work, workload and stress levels, interactions with coworkers and supervisors, access to paid leave, and health-promoting workplaces all can have an important impact on the well-being of workers, their families, and their communities.<sup>39-42</sup>

In addition to hazard control and facility design, TWH strategies include interventions supporting healthful communities, fair and adequate compensation and benefits, healthy leadership, organizing work to mitigate stress, health-supporting workplace policies such as paid sick leave and predictable scheduling, prevention of any adverse effects of technology, being responsive to the impact of both traditional and nonstandard work arrangements, and consideration of how people of different ages from different cultural, economic, and educational backgrounds experience work and its hazards.<sup>43,44</sup> The program funds academic Centers of Excellence for *Total Worker Health* that conduct research and develop pilot interventions.<sup>45</sup>

### **ACCOMMODATING WORKERS WITH DISABILITIES**

Design issues related to accommodations for workers with disabilities include accessibility/mobility, hearing, vision, and cognition<sup>46</sup> (chapter 10). For example, a restroom may be modified to meet accessibility requirements, including wider doors and stalls and grab bars suitable for use by persons in wheelchairs. Workplaces must include provisions for emergency evacuation and parking accom-

modation. Reasonable accommodation may also include modifying an employee's workstation or providing a special chair. Design and policy approaches are both important in providing accommodations for workers with disabilities. The Job Accommodation Network provides a wide range of technical assistance to support the employment of people with disabilities.<sup>47</sup>

### **COMMUNICABLE DISEASE CONTROL**

To reduce the risk of disease transmission through surface contact, there is an increasing use of "no-touch" building controls, such as automatic doors, automatic toilets, soap dispensers, disinfectant dispensers, faucets, and hand dryers. Restrooms can be designed to allow occupants to exit without grasping a pull-door handle. Waste receptacles can be located close to doors for paper towels used for grasping door handles. Workplaces can replace water fountains with no-touch water dispensers to fill employees' individual water bottles. Water or waterless sanitation handwashing should be provided in all types of workplaces, including for outdoor workers such as farmworkers and underground workers such as miners.

Airborne transmission control has been a priority in recent pandemics. To reduce the risks for diseases transmitted via airborne droplets from coughing or sneezing, a six-foot separation distance between workers or between workers and the public is commonly used. For diseases transmitted by aerosols that do not easily settle to the ground, a well-maintained ventilation system with sufficient fresh air and filtration is important.<sup>48</sup> Higher percentages of outside air are helpful, although there are limits based on local climate and system capabilities. Some building sustainability and health certification criteria (see Fitwel and WELL in chapter 22) give added credit when fresh air supplies are increased, which must be balanced with energy-efficiency goals. Many building systems are also able to handle finer filtration media, such as replacing MERV 8

filters with MERV 13 or higher. A source of expert guidance on ventilation is the **American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)**.<sup>49</sup>

Limiting room and building occupancy is another strategy for reducing the concentration of infectious aerosols. Some workplaces have reduced elevator occupancy and changed walking paths to make maintaining distances between people more feasible. Where closer interactions are needed, barriers have been used, often clear glass or plastic, or higher cubicle partitions. In situations such as the COVID-19 pandemic, these strategies appear to be most effective when used in conjunction with requirements for wearing a respirator or other type face mask—provided such masks fit well with minimized leaks, cover both nose and mouth, and do not have exhalation valves. When respirator use is necessary in a workplace, employers should implement a formal program that ensures proper respirator selection and fit, as well as training on the use and limitations of respiratory protection.

**Ultraviolet germicidal irradiation (UVGI)** can be effective for killing or inactivating contagious particles and may be used in conjunction with other techniques such as dilution or filtration. Because direct UV rays are harmful to the eyes, use in occupied rooms is limited to upper room systems that prevent direct viewing of the bulbs. Other uses include UV lighting inside air ducting and portable UV sterilizing units temporarily placed in an area when no unprotected occupants are present. Combining techniques is an option, such as using MERV 13 or better air filters for primary control and UVGI for high-risk areas such as restrooms or health care common areas. ASHRAE provides guidance on UVGI usage.<sup>50</sup> Also important are workplace policies and education emphasizing such practices as coughing and sneezing etiquette, frequent hand washing, and the importance of staying home when sick. Flexible sick leave policies encourage and

enable sick employees to stay home, reducing risk to others at work.

## PSYCHOSOCIAL WORKPLACE HEALTH

In seeking to design and manage a pleasant and health-promoting workplace, consideration should be given to the goals and benefits of a psychologically healthy workplace, including the following<sup>51</sup>:

- Civility and respect in the workplace
- Supported and valued employees
- Praise, recognition, acknowledgment, and fairness
- Growth and development opportunities
- Clear leadership and expectations
- Recognition of the need for healthy work-life fit with personal, family, and community demands
- Manageable, reasonably paced workloads, assuring that responsibilities can be accomplished within the time available
- Adequate resources to do the job
- Input/control over work organization
- Consideration of opinions and suggestions of employees—employees participate in decision-making
- Psychological services and supports available to employees when mental health issues occur

Canadian and international voluntary standards including guidance and resources to support psychological health and safety in the workplace are available.<sup>52,53</sup>

## WORKPLACE VIOLENCE

In a National Safety Council survey, 22 percent of workers reported being exposed to workplace violence, 12 percent reported that it has caused or contributed to a serious injury in their workplace, and 47 percent reported that their job offered workplace violence training. Additionally, 91 percent of employers said they are prepared to avoid incidents of workplace violence.<sup>54</sup>

Improved psychosocial workplace health may contribute to reductions in violence,

and so may the design of the workplace itself. Workplace design should include elements to protect workers from violent acts by members of the public and by other workers. For internal workplace security, secured and monitored entrances and alarmed exits should be considered in workplace designs. More rigorous design elements are needed to protect workers who interact with the public, such as those in convenience stores, gas stations, banks, fast-food restaurants, and post offices, or those in work settings that must protect both workers and their charges, such as health care facilities and schools.<sup>55</sup> Additional security provisions are needed for workplaces such as airports, government installations, chemical plants, and nuclear facilities that may be at risk for terrorist attacks.

Crime prevention through environmental design (CPTED) can reduce violence by thoughtful design and organizational choices (chapter 5). For example, keeping clear lines of sight and visibility from the outside for retail cashier areas, or areas of high-value merchandise, can dissuade thefts and potential violence. Trade-offs may be needed. For example, if a pharmacy is far away from the storefront windows, thefts may be more likely—yet this design may encourage customers to buy more items en route to the pharmacy counter. Guidelines to prevent crime and violence through environmental design can be categorized into four focus areas<sup>56-58</sup>:

- Natural surveillance: Highly visible work areas (well lit, windows not blocked by excessive signage or other objects or plants, hidden areas reduced)
- Natural access control: Removing straight-line access (landscaping, curbing, vehicle and pedestrian pathways, lobby layout designs)
- Territorial reinforcement: Distinguish between legitimate occupants and intruders (entry signs, access control, visitor badging, receptionists clearly see entrances)

- Maintenance: Keeping a workplace maintained, sending the message that people care about and notice what happens in the area

## **SOCIALLY RESPONSIBLE SUSTAINABILITY**

The twin goals of designing and maintaining healthier workplaces and conservation of limited resources are compatible. Dangerous work does not conserve human resources, and newer “green” technologies are not sustainable if they are dangerous. Solar panels, wind turbines, and large storage batteries are environmentally favorable, but operations to build and maintain them come with electrical and falling hazards. Energy-saving efforts like weatherization, renovation, and insulation can result in worker exposure to lead, asbestos, and isocyanate hazards during renovation or installation.

Documenting more sustainable, safer, and healthier business through metrics, levels, or report cards not only indicates success, but can be a competitive advantage. Setting measurable, achievable, time-sensitive goals and milestones is important to achieve sustainable beneficial change. For example, in addition to energy efficiency, key sustainability metrics now often include social aspects such as worker safety, health, and wellness. The US Green Building Council certification program, Leadership in Energy and Environmental Design (LEED), now includes a prevention through design certification credit.<sup>59</sup> This credit expands the consideration of worker health and safety to all occupants during the **facility life cycle**, including early occupants (construction workers) and supporting occupants (operations and maintenance workers). The LEED PtD credit includes a process similar to the *Design Safety Review* process outlined earlier. Since LEED certification is used around the world, requiring use of the LEED PtD credit may be a practical way to include prevention through design collaborative planning and review in new facility designs.

Beyond green buildings, the previously mentioned GRI sustainability reporting stan-

dards now include *worker* sustainability metrics.<sup>36</sup> Just as environmental sustainability is improved when complying with such standards, sustainable worker safety and wellness are now benefiting from similar focus as businesses use these standards to compete internationally.

#### **GLOBAL SUSTAINABILITY—FREE TRADE, FAIR TRADE, STANDARDIZATION**

The worst of the worker hazards of the Industrial Revolution, whether child labor or grossly unhealthy and unsafe labor, still exist today in some types of work, especially in low- and middle-income nations. Whether garment sweatshops in Asia, deadly mining in Africa, suicides related to intense assembly line pressures,<sup>60</sup> or the dangers to immigrant day laborers working in North America, free trade is not necessarily fair trade at the worker's level. Regulations are crucial to advancing labor protection, as are grassroots efforts such as those promoting "fair trade" goods through labeling and advertising.

Although international commerce and free trade can indirectly give preference to the low initial costs of an unregulated and endangered workforce, they are likely to have unintended consequences. The standardization of international commerce with commitments to international standards and norms—monitored and verified—can improve worker conditions. To sell in a particular nation, a business must meet that nation's standards. If the business wants to market to many of the world's nearly two hundred nations, it is often more practical to comply with a single set of international standards that most nations accept, providing motivation to meet such standards.

Many nations now participate in international standards to enhance their economies. Compliance with such standards is reported in the promotional and financial reports of a business as a sign of stability and corporate responsibility. For example, the International Organization for Standardization (ISO)

publishes the ISO 9000 family of standards for quality management and the ISO 14000 family of standards for environmental management that are used by many corporations. Of major importance to workers, especially in developing countries with little national regulation or enforcement, are the newer ISO 45001 standards for occupational health and safety. These standards, developed with the involvement of more than seventy countries, have the potential to improve occupational health and safety management around the world and to promote socially responsible sustainability efforts.<sup>35</sup> The US and international standards are freely available on the web.<sup>25,34,35</sup> Although large corporations may adopt international standards, workplaces in different countries may have different expectations for protecting the health and safety of workers based on their local cultures.<sup>61</sup>

#### **MIGRANT AND UNDOCUMENTED WORKERS**

Unauthorized resident status is often accompanied by a degree of worker vulnerability and less consideration by employers for workers' safety. To make a good impression, employees may start working at an unsustainably high pace, which then becomes the expected norm. They may also be constrained from reporting problems at work to supervisors or to government agencies with oversight responsibilities for fear they will be fired or deported. Employers may replace local workers with additional undocumented workers, leading to unsafe expectations across the workforce. Fearing repercussions from hiring undocumented workers, some employers will not request emergency assistance or outside services, such as an ambulance, when needed. Workers' coping strategy may result in disregarding threats to their health and safety to minimize conflicts or legal dangers.<sup>62</sup> Inclusion of migrant health into efforts such as the International Labour Organization (ILO) decent work agenda,<sup>63</sup> the UN agenda for sustainable

development,<sup>64</sup> and the UN Global Compact on corporate sustainability<sup>65</sup> could help leverage technical resources, programs, and research to forge partnerships to better understand and improve the health status of the world's migrant workers.<sup>66</sup>

## WORK EQUITY

There is increasing recognition that a business without *social equity* is not sustainable. In addition to designing a safe facility, social equity in the workplace should consider such issues as the needs and disparities in the surrounding community, workforce compensation and development, and the supply chain supporting a business.<sup>67</sup>

Some lower-skilled or lower-paid workers, such as meat packers, grocery workers, and crop pickers, sometimes have the most strenuous work. Others, such as sanitation workers and health care workers, may be exposed to higher health hazards. Lower pay should not translate to lower efforts to protect workers, and management is encouraged to protect all workers with equal effort. In fact, the work environments of lower-paid workers frequently need continual attention to assure the workers' safety and health. Socially responsible sustainability can contribute to long-term business success.

## THE CHANGING NATURE, OR FUTURE, OF WORK

The nature of work is changing for many people. Influences include changes in technology, demographics, globalization, urbanization, climate, economic conditions, and **telework**. Also changing is the so-called gig or "platform" economy in which, for example, work is accepted on a smartphone app and both the employer and place of work can change daily. Some of these new technologies and work arrangements have the potential for social isolation, loneliness, or frequently changing workplaces, increasing the exposure to novel hazards for which the worker may be ill-prepared.

When applied appropriately, new technologies such as computing, automation, robotics, predictive analytics, and artificial intelligence can assist in ensuring a safer work environment. Such technologies can also enhance human abilities to do new types of work. New jobs for specialists in these technologies are also created. Although technological advances have historically produced more jobs than they have eliminated, some literature suggests this trend may not continue.<sup>68</sup>

Although worker benefits can be many, including improved health and safety, some workers will suffer the anxiety of potential job loss or the stress of unemployment—great health risks in themselves. Successful businesses involve specialists, managers, and experienced workers in collaborative efforts to prepare the workplace and the workforce for changes to come. Workers know the work best, specialists know the changes best, and management knows the financial and market possibilities and limitations best. Such collaboration can reduce anxieties about potential changes. Continuing education and training are often recommended to meet changing business needs and raise morale and reduce anxiety, thus contributing to more successful work teams. Some workers may use their enhanced skills to find a position elsewhere, by choice or necessity, but until that time, their increased skill and motivation benefit both them and their employer.

Some literature suggests that jobs will be fewer with a bifurcation of types of jobs to either high- or low-skill levels as automation replaces jobs of medium skill level. If there are fewer jobs, workers who do not find new jobs will require supportive services and resources that may not be adequately available. Meeting such needs with creative options will require broader societal actions beyond those of individual businesses.<sup>69</sup>

The future of work involves changes to the workplace, work, and workforce in the context of changing national and global political and environmental issues. In 2019, NIOSH

launched its Future of Work initiative to investigate emerging occupational safety and health issues.<sup>70,71</sup> Some of its priority topics related to the built environment component of the workplace include emergency preparedness, workspace, automation, robots, and human-machine interfaces.

## CONCLUSION

Well-designed workplaces keep workers safe; support engaging, meaningful work; encourage healthy behaviors; and support worker equity as part of planned administrative and supervisory policies, practices, and programs. Worker equity is improved when a design approach is used, as benefits are experienced by both high- and low-paid workers and by workers of all levels of influence within an organization. Considering that the time spent in the workplace is usually second only to the time spent in the home, designing workplaces to both protect and promote the safety, health, and well-being of workers is both a significant opportunity and a critical public health priority.

**Disclaimer:** The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

## DISCUSSION QUESTIONS

1. What workplace design elements might be most effective in protecting workers from injury? Which elements might be most effective in assuring and promoting the overall health of workers? Which elements might affect both worker safety and worker health?
2. What policies and programs can be used in workplaces to maximize worker interaction with the built environment to promote health?
3. What are the limitations of the built environment in protecting and promoting the health and safety of workers?
4. Workers have fewer work-related injuries today as a result of laws, regulations, and enforcement policies than they have in the past. What are the benefits, risks, and barriers to using mandatory interventions to promote the overall health of workers both on and off the job?

## DISCLOSURE OF COMPETING INTERESTS

Jonathan A. Bach, Paul Schulte, L. Casey Chosewood, and Gregory R. Wagner disclose no competing interests.

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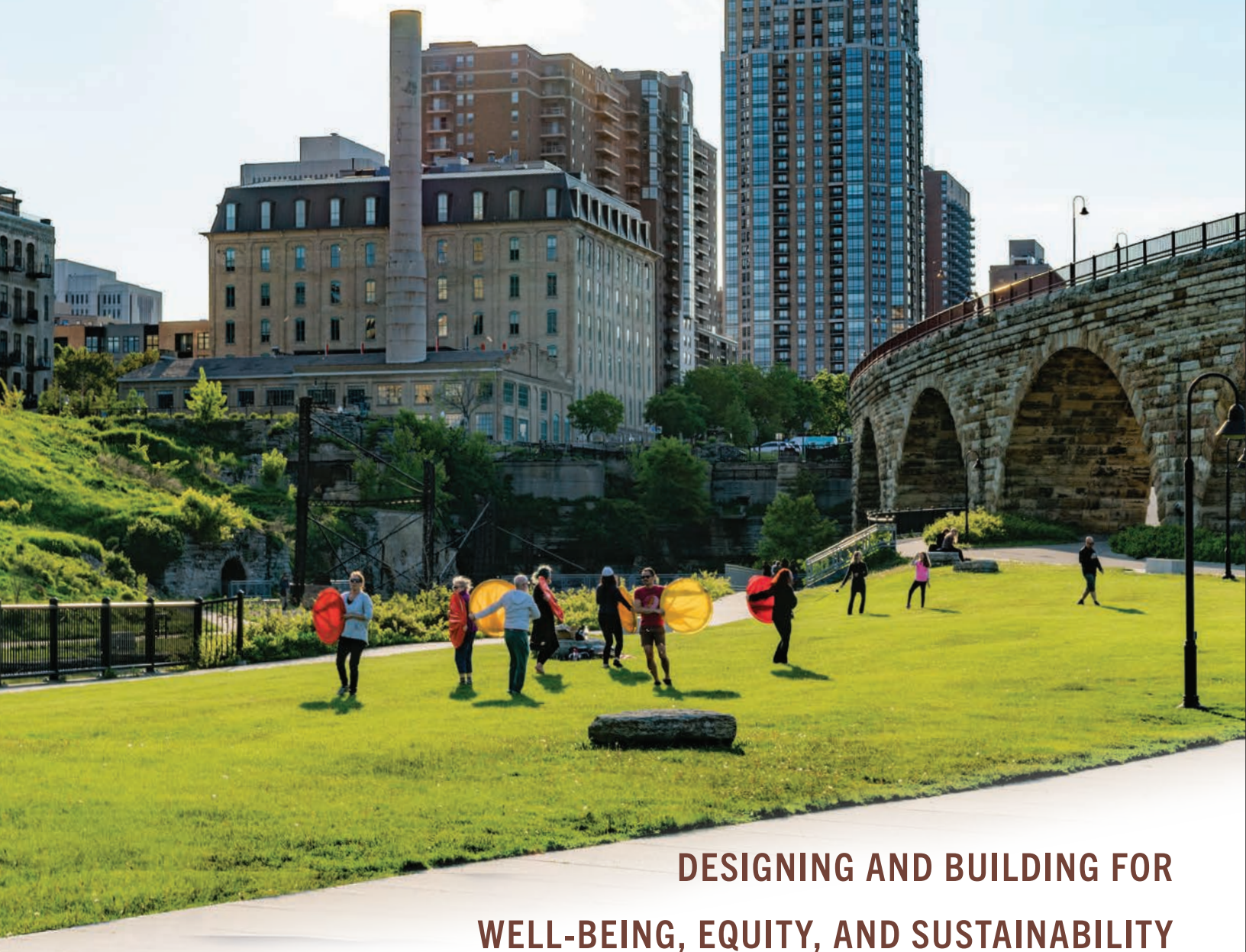
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# Making Healthy Places

Edited by NISHA BOTCHWEY,  
ANDREW L. DANNENBERG,  
and HOWARD FRUMKIN

SECOND EDITION



DESIGNING AND BUILDING FOR  
WELL-BEING, EQUITY, AND SUSTAINABILITY

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