Physical Hazards

On Christmas Eve, 2009, six employees of Metron Construction were repairing balconies at a Toronto high-rise apartment. All the men were newcomers to Canada, hailing from Latvia, Uzbekistan, and Ukraine. They were on a swing-stage scaffolding (the type of suspended scaffolding you often see on the outside of tall buildings) working on a 13th-floor balcony. Their project manager, Vadim Kazenelson, was on the balcony handing them tools. As Shohruh Tojiddinov, one of the workers on the scaffolding, later reported, Kazenelson decided to climb on to the scaffolding. “He said ‘where is the lifeline’ and [the site supervisor Fayzullo] Fazilov said ‘don’t worry’. . . . [Kazenelson] jumped onto the stage and the stage broke. “ Tojiddinov was wearing a harness and when the stage broke he was left hanging in mid-air. “I looked up and I saw Vadim pulling me up. . . . I saw four deaths and one was still alive. I vomited. ”

As Kazenelson landed on the scaffolding, it split in two. Kazenelson was able to scramble back onto the balcony. The other five men fell to the ground, instantly killing four (Alesandrs Bondarevs, Aleksey Blumberg, Vladamir Korostin, and Fazilov). The fifth, Dilshod Marupov, was left permanently disabled. The scaffolding had only two lifelines available for the seven men and Tojiddinov was the only one using the fall protection. The scaffolding had been provided to Metron by Swing N Scaff Inc., a scaffolding supply company.

Learning Objectives

After reading this chapter, you will be able to:

- Define physical hazards and explain how they operate.
- Describe root and proximate causes of physical hazards and how they affect hazard control.
- Identify techniques to control workplace noise.
- Explain why vibration is a hazard and consider control options.
- Discuss why radiation and temperature extremes are hazards and consider control options.
- Outline the longer-term health effects of work design and the principles of ergonomics.
On Christmas Eve, 2009, six employees of Metron Construction were repairing balconies at a Toronto high-rise apartment. All the men were newcomers to Canada, hailing from Latvia, Uzbekistan, and Ukraine. They were on a swing-stage scaffolding (the type of suspended scaffolding you often see on the outside of tall buildings) working on a 13th-floor balcony. Their project manager, Vadim Kazenelson, was on the balcony handing them tools. As Shohruh Tojiddinov, one of the workers on the scaffolding, later reported, Kazenelson decided to climb on to the scaffolding. “He said ‘where is the lifeline’ and [the site supervisor Fayzullo] Fazilov said ‘don’t worry’. . . . [Kazenelson] jumped onto the stage and the stage broke.” Tojiddinov was wearing a harness and when the stage broke he was left hanging in mid-air. “I looked up and I saw Vadim pulling me up. . . . I saw four deaths and one was still alive. I vomited.”

As Kazenelson landed on the scaffolding, it split in two. Kazenelson was able to scramble back onto the balcony. The other five men fell to the ground, instantly killing four (Alesandrs Bondarevs, Aleksey Blumberg, Vladamir Korostin, and Fazilov). The fifth, Dilshod Marupov, was left permanently disabled. The scaffolding had only two lifelines available for the seven men and Tojiddinov was the only one using the fall protection. The scaffolding had been provided to Metron by Swing N Scaff Inc., a scaffolding supply company.
The investigation that followed the incident revealed that the scaffold was faulty and had not been designed or inspected properly by Swing N Scaff. It also found that the men, whose knowledge of English was limited, were not provided with any training about working at heights or using fall protection.² There was insufficient fall protection gear available to secure all the men. Subsequently, Kazenelson attempted to cover up the incident. He told Tojiddinov to say that Kazenelson had been on the ground and he gave him a safety manual on fall protection (in English, which Tojiddinov could not read), instructing him to say he had received it before the incident.³

This incident dramatically demonstrates what can happen when an employer fails to protect their workers from physical hazards. In this case, the employer failed to provide the workers with safety training and equipment to protect them from the primary hazard (falling from a height). The danger of the hazard was compounded by the workers’ limited ability to enforce their safety rights due to their limited language skills, minimal knowledge of health and safety laws, and weak negotiating position as new Canadians.

As we saw in Chapter 3, a hazard (which is sometimes called an agent) is anything that might harm, damage, or adversely affect any person or thing under certain conditions at work. It can be an object, process, context, person, or set of circumstances that has the potential to create negative health and safety outcomes. In this chapter, we will focus our attention on physical hazards. A physical hazard typically (but not always) entails a transfer of energy that results in an injury, such as a box falling off a shelf and hitting a worker or a worker falling from a scaffold and hitting the ground.

Physical hazards are the most widely recognized hazards and include contact with equipment or other objects, working at heights, and slipping. This category also includes noise, vibration, temperature, electricity, atmospheric conditions, and radiation. More recently, OHS practitioners have also included the design of work and the workplace as physical hazards, suggesting it is important to attend to the ergonomic effects of work. This chapter discusses how to identify physical hazards and to determine ways to control some of the more common physical hazards. In discussing physical hazards, it is important to keep in mind that non-traditional work relations, such as the one highlighted in the opening vignette, can compound the risk associated with a physical hazard. We discuss the health and safety implications of non-traditional work relations more fully in Chapter 7.
IDENTIFYING PHYSICAL HAZARDS

In 2012, 50% of all WCB time-loss injuries in Canada were caused by physical hazards. Injuries caused by contact with an object/machine or falls was the most common type of injury.¹ Injuries caused by physical hazards are both overrepresented and underestimated in mainstream OHS. As we saw in Chapter 1, physical hazards are overrepresented in media portrayals of workplace incidents because they conform to commonly held views of safety hazards.² Hazards such as a slippery floor or an unguarded saw blade are easy to imagine and their effects on workers’ health are clear and direct.

At the same time, employers often underestimate the prevalence of (and thus fail to control) physical hazards. For example, an extension cord lying across a hallway floor is often seen as no big deal because it is a readily apparent and easily understood tripping hazard that we expect workers to avoid as a matter of course (“pick up your feet!”). When such hazards result in an injury, we often blame the worker for her inattention to the hazard rather than examine why the hazard was present and why the hazard was not controlled. The loose extension cord, for example, could have been eliminated as a hazard by re-running the wiring through the ceiling or moving the powered device closer to the plug in.

This example is a reminder that the definition of cause affects decisions about injury control. If worker carelessness or inattention is deemed to be the cause of an incident, then the controls will focus on correcting the worker rather than removing the hazard. Indeed, often the nature of physical hazards lends itself to devising “simple” solutions designed to alter worker behaviour rather than controlling the hazard itself. For example, the contact hazard posed by a doorway with unusually low clearance may be addressed by posting a sign saying “caution: low doorway” and expecting workers to duck as they pass through it. A more effective (but costlier) solution is to increase the doorway’s height.

Physical hazards also sometimes hide in plain sight. Often a hazard is so pervasive or workers’ behaviours to avoid the hazard are so routinized that the hazard is rendered almost invisible. For example, workers in a kitchen may use a dishtowel when opening an oven door to prevent the hot handle from burning them. Habitually turning a dishtowel into PPE prevents the injury and renders the hazard invisible. When identifying physical hazards, it is important to adopt the outlook of someone new to the workplace to bring back into view any hazards that have become invisible over time.
Box 4.1 Preventing slips, trips, and falls

What is the most effective way to prevent slips, trips, and falls in the workplace? This is an important question. In 2012, 18% of all Canadian lost-time claims involved a worker falling, either from a height or on the same level.\(^6\) This figure significantly underrepresents the total number of incidents, as many slips and trips do not result in injury requiring time off work.

Most studies of trips and falls focus on factors related to workers, such as what caused workers to lose their balance, workers’ demographic characteristics, or whether workers followed safety principles they were taught in training.\(^7\) Despite many such studies, most injury prevention efforts have been ineffective at reducing the incidence of slip, trips, and falls.\(^8\) This may indicate that these studies are focused on the wrong issues.

In a recent analysis, Tim Bentley argues that the study of slips, trips, and falls has been focused too narrowly on what he calls the “active failures” that lead to incidents. Active failures are the immediate factors that lead to risk of injury, including individual factors connected to the time and place of the event such as demographics, perception, use of equipment, and the exposure to the hazardous situation.

Bentley calls for greater emphasis on latent failures, which are the “conditions that elicit substandard or unsafe behaviours that are present in the system without causing immediate threats but have the potential of being a step in an injury event.”\(^9\) These include factors such as workplace design, the organization of work, management decisions, and environmental conditions such as climate. He argues that the perceptions and decisions made at the moment of active failure are shaped and bounded by existing latent failures.

The core of Bentley’s argument is that it is easy to look at who the worker was (e.g., a new worker) and what they were doing at the moment of the fall (e.g., not paying attention). As a result, most injury prevention efforts are focused on the worker. Bentley argues that employers should be focusing on the latent features of the incident—the pace of work, the design of the workplace, stress levels, and other
Bentley’s approach is similar to the notion of proximate and root cause discussed in Chapter 1. Essentially, injury prevention is more effective if we look beyond the obvious causes to see the underlying causal factors. This more holistic approach is supported by studies that suggest the most effective method for preventing slips, trips, and falls is to adopt a multi-faceted approach that includes enhanced hazard assessment, preventive design changes, training, management leadership, and greater attention to environmental factors.¹⁰

**NOISE AND VIBRATION**

Noise and vibration are related physical hazards that are treated very differently in OHS regulation and management. Noise has been well studied and there is a long (albeit incomplete) list of rules for controlling noise hazards. By contrast, less than half of Canadian jurisdictions have any regulations governing vibration exposure. This section examines the nature of each hazard, their health effects, and briefly considers effective control options.

*Noise* is simply defined as sound energy that moves through the medium of the air. More scientifically, sound consists of small air-pressure changes caused by the vibration of molecules. The energy from the molecules exerts influence on neighbouring molecules, causing the sound to disperse throughout an area. Human eardrums are designed to detect the small pressure changes and then transfer them through a network of three bones to the inner ear where tiny hair-like cells turn the vibrations into electrical impulses interpreted by the brain. Noise is always present around us.

Noise can damage the structures of our ears and lead to hearing loss. Noise can also cause other health effects (see below). Three characteristics of noise affect whether it becomes a hazard: frequency, duration, and loudness.

- **Frequency** is vibration of the medium (e.g., air molecules) through which sound energy moves. We measure frequency in Hertz (Hz) (i.e., the number of vibrations per second). We experience sound frequency as the pitch of noise. Fast vibration yields a higher-pitched noise
than slow vibration. We can normally hear sounds with frequencies between 20 Hz and 20,000 Hz. Sounds extending beyond the low and high end of our hearing range are not registered by our brains (i.e., we cannot hear them), but they can still harm our ears.

- **Duration** is the length of time a worker is exposed to noise. How long a worker is exposed to noise is important. Yet, as discussed below, even short-term exposure can cause damage, especially if the noise is sudden and at a high frequency.

- **Loudness** (or intensity) is the amount of energy that is being carried through the medium. Loudness is measured in decibels (dB). The key feature of decibels is that they are a logarithmic scale. Unlike linear scales (where each step on the scale represents the same increase, such as a car’s speedometer), each increase on a logarithmic scale is an order of magnitude greater than the previous increase. For example, a sound measured at 10dB is 10 times more intense than a sound measured at 0dB (the lowest audible sound). But a sound measured at 20dB is 100 times more intense than the sound measured at 0dB. Noise over 85dB is generally considered hazardous for human hearing.

The mostly widely accepted health effect of noise exposure is hearing loss. If the loss is temporary, such as after a music concert, it is called a *temporary threshold shift* (TTS), meaning the normal range of human hearing has been reduced. This effect usually reverses itself over a short period of time. Nevertheless, TTS is a signal that the noise exposure was harmful and that continual or repeated exposure can accumulate and lead to *permanent threshold shift* (PTS). Men typically have higher rates of PTS. Some of this gender effect is due to job segregation (i.e., men typically work in louder workplaces than women). It is also possible that some of this effect reflects physicians failing to link female hearing loss to occupational exposures. Women are often exposed to noise in food, bottling, and textile factories as well as service industry jobs.

Extended exposure to noise hazards can lead to non-hearing health effects as well. It can induce a sensitive startled response to sound and cause changes in endocrine and biochemical systems, nausea, headaches, and constricted blood vessels. Sound can also create health effects without prolonged exposure. *Acoustic trauma* is caused by a short, intense exposure to noise, usually
of high frequency (see Box 4.2). Exposure to this hazard can lead to a series of short- and long-term health effects. Short-term effects include a full sensation in the ears, sharp pain around the ear, nausea, or dizziness. Longer-term effects can include headaches, fatigue, anxiety, and hypersensitivity to sound.\(^{13}\)

**Box 4.2 Acoustic trauma in call centres**

Workers in call centres, often women, immigrants, and young workers, are exposed to a variety of physical and psycho-social hazards. Exposure to noise is not regarded as a significant source of ill health. While call centres can be loud places, testing has found that noise exposure is usually well under the regulated exposure limits (85dB over 8 hours). Traditional analysis has suggested minimal risk for hearing loss.

Recently, however, studies in Sweden, Europe, and Australia have reported on growing incidence of acoustic trauma, sometimes called acoustic shock, among call centre workers.\(^{14}\) The trauma is the result of sudden, intense, startling, and often high frequency sounds emitted through the telephone headset, frequently described as a squawk or squeal. Often the sounds are loud (over 100dB), but the negative effects do not seem to be connected to volume and are more associated with the sudden, sharp nature of the sound. Following the incident, workers report pain, tinnitus (ringing in the ears), loss of balance, nausea, and sensitivity to sound. Symptoms might last from a few minutes to days. Increased frequency of incidents appears to increase the intensity and length of the symptoms.

For a long time, these worker reports were not taken seriously as their experience did not fit the traditional view of hazardous noise exposures. Most call centre systems have sound inhibitors cutting out any noise that exceeds about 115dB. Considering that the natural response to such a sound is to remove the headset quickly, it was determined they would only have a few seconds exposure and thus would not be at risk of hearing loss. Only when additional research was conducted, spurred on by a campaign from the Trade Union Confederation in England, did the medical evidence appear to support worker reports of ill health caused by short and intense sounds.
All jurisdictions in Canada regulate workers’ exposure to noise. Most jurisdictions utilize an exposure model that factors in duration and loudness, known as a time-weighted average (TWA). Government regulations use dB(A), which is a weighted measure of loudness that factors in the frequency of the noise. Lower-frequency noises are weighted in the calculation so that their dB(A) is lower than their unadjusted dB. This reflects a belief that lower-frequency noises are less harmful than higher-frequency noises.

The regulations generally seek to limit worker’s noise exposure to no more than 85dB(A) during an eight-hour shift. The duration of acceptable exposure declines by half for every 3dB(A) increase. So acceptable worker exposure drops to 4 hours at 88dB(A), 2 hours at 91dB(A), and so forth. The logic of TWA leads to a ceiling of noise exposure at approximately 115dB(A). Box 4.3 provides some real life examples of these noise levels.

There are significant shortcomings in this approach to regulating noise exposure. First, while the use of dB(A) does partially address the issue of frequency, regulations do not adequately address the health effects of short, intense, and high frequency sounds, such as those that cause acoustic trauma. Second, there is insufficient evidence to determine if an exposure at 85dB every day over a period of many years is safe. Third, the rules do not account for individual variation. Research has established that people possess different degrees of sensitivity to noise. Some have greater physiological and psychological reactions to lower levels of noise, while others appear to be more tolerant. As with other types of hazards (e.g., carcinogenic substances), some individuals appear to be more susceptible to harm than others. The reasons are complex, but a universal standard designed to address the so-called “average” person will leave some workers inadequately protected from noise hazards.

<table>
<thead>
<tr>
<th>Box 4.3 Decibel equivalencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>The table below provides examples of the noise levels of common items and indicates how long government OHS regulations permit exposure to those noises. A question to ask yourself is whether you would like to be exposed to that noise for the prescribed length of time (e.g., a truck backup alarm for eight hours)? Do you think such an exposure might affect your health?</td>
</tr>
</tbody>
</table>

76 Health and Safety in Canadian Workplaces
Vibration is the oscillating movement of a particle around its stationary reference position. In the workplace, a mechanical process usually causes vibration. Vibration becomes a hazard when workers come into contact with the vibration, causing energy to be transferred to the worker. Two types of workplace vibration are important for OHS. Whole-body vibration occurs when a worker’s entire body experiences shaking caused by contact with the vibration. This is most common with low-frequency vibration (below 15 Hz), as when driving in a car or working near a large machine, such as an air compressor. The health effects of whole-body vibration include a general ill feeling, nausea, motion sickness, and increased heart rate. Extended exposure to whole-body vibration can lead to lower-spine damage and, sometimes, internal organ damage.

Segmental vibration occurs when only parts of the body are affected by the vibration. This is usually caused by higher-frequency vibration. The most common and concerning form of segmental vibration is hand-arm vibration. Hand-arm vibration results from gripping power tools such as

<table>
<thead>
<tr>
<th>Decibels (dB(A))</th>
<th>Item</th>
<th>Regulatory Time Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Refrigerator</td>
<td>n/a</td>
</tr>
<tr>
<td>60</td>
<td>Conversational speech</td>
<td>n/a</td>
</tr>
<tr>
<td>75</td>
<td>Vacuum cleaner</td>
<td>n/a</td>
</tr>
<tr>
<td>80</td>
<td>Alarm clock</td>
<td>n/a</td>
</tr>
<tr>
<td>85</td>
<td>Truck backup alarm</td>
<td>8 hours</td>
</tr>
<tr>
<td>90</td>
<td>Lawnmower</td>
<td>2.6 hours</td>
</tr>
<tr>
<td>95</td>
<td>Food processor</td>
<td>50 minutes</td>
</tr>
<tr>
<td>100</td>
<td>Motorcycle</td>
<td>15 minutes</td>
</tr>
<tr>
<td>100</td>
<td>Handheld drill</td>
<td>15 minutes</td>
</tr>
<tr>
<td>110</td>
<td>Jackhammer</td>
<td>1 minute 38 seconds</td>
</tr>
<tr>
<td>115</td>
<td>Emergency vehicle siren</td>
<td>0 seconds</td>
</tr>
<tr>
<td>120</td>
<td>Thunderclap</td>
<td>0 seconds</td>
</tr>
<tr>
<td>140</td>
<td>Jet engine takeoff</td>
<td>0 seconds</td>
</tr>
</tbody>
</table>
Jackhammers, saws, and hammer drills. An important aspect of hand-arm vibration is that a tight grip is required to control the vibrating tool, but the tighter the worker grips, the worse the effects of the vibration. Hand-arm vibration syndrome (sometimes called Raynaud’s phenomenon or “white finger”) is caused by restriction of blood and oxygen supply to fingers and hands, which causes damage to blood vessels and nervous systems. The first symptoms are tingling in the fingers, loss of sensation, loss of grip strength, and whitening of the fingers when exposed to cold. Initially, these effects are reversible, but over time they become permanent. Because vibration is the movement of particles, it is related to noise and is often associated with noise exposure. As with noise, individual susceptibility to vibration exposure effects varies. How hard the worker grips the tool, their posture, their sensitivity to motion sickness, and other factors can shape how the exposure manifests itself, which can make it difficult to ascertain the seriousness of the health risk. Men most often manifest vibration-related injuries, reflecting occupational segregation. That said, women in some female-dominated occupations (e.g., dental hygiene) frequently report vibration-related injuries. Exposure to vibration, while widely recognized as a safety hazard, is largely unregulated. Only British Columbia has standards restricting exposure to types of vibration. Those rules adopt a time-weighted average approach similar to that used for noise regulations.

Noise and vibration are measured in similar ways. Both require a specialized meter to detect the intensity of the molecular movement. These meters can provide accurate measurements of real-time levels. Nevertheless, the meters cannot assess the susceptibility of a worker to noise/vibration exposure, nor the degree of damage sustained by the exposure. This means that, even if vibration standards are established, workers may still be harmed by these hazards. OHS regulations also require that workers exposed to noise undergo regular audiometric testing to detect any threshold shift (there are no equivalent requirements for vibration exposure).

Controlling noise and vibration hazards is a complex undertaking. In both cases, the most effective way to control the hazard is elimination, substitution, or engineering controls. Such controls can be expensive, as they require replacing machinery, altering processes, or eliminating tasks from the workplace. Controls along the path can also be implemented by erecting sound barriers to muffle noise or installing vibration resistant material on tool
handles. The most common, yet least effective, controls for noise and vibration are time restrictions and PPE. Restricting workers’ exposure to noise or vibration can reduce the effect of these hazards but does not address the full range of risk to the worker.

**TEMPERATURE**

Humans are a temperature-sensitive species and have evolved a finely tuned system that regulates our internal temperature. Under normal circumstances, the body interacts with its environment to maintain a core body temperature at about 37 degrees Celsius. When the environment becomes too cold or hot, our bodies have difficulty generating or shedding sufficient heat to maintain **temperature homeostasis**.

When temperature extremes prevent our bodies from properly self-regulating, we experience **thermal stress**. Temperatures that are too high can lead to **heat stroke**. Early signs of heat stroke include fatigue, dizziness, confusion, lightheadedness, nausea, and sudden, unexplained mood swings. Prolonged exposure leads to fainting and death. Heat stroke can cause damage to muscles, the heart, kidneys, and the brain. Humidity interferes with the body’s ability to shed heat (through sweating) and, therefore, can lower the temperature at which thermal stress occurs. Conversely, when temperatures are too low, we can experience **hypothermia**. Initial symptoms of hypothermia include dizziness, fatigue, nausea, sudden euphoria, or irritability. Pain in extremities and severe shivering may also occur. Advanced hypothermia can lead to frostbite and frozen extremities, and unconsciousness leading to death. Wind can intensify the effects of cold, as it strips heat away from the body.

Exposures to extreme temperature are most common among workers working outdoors, although thermal stress can occur in some indoor locations (e.g., a meat cooler or a non-air-conditioned office on a hot summer day). Employers should also pay attention to **thermal comfort**. Thermal comfort is the condition in which a person wearing normal clothing feels neither too cold nor too warm. It is a function of temperature, humidity, and air movement within an indoor workplace. A lack of thermal comfort may not pose a direct health risk, but it can exacerbate existing hazards or be a factor that increases risk of an incident occurring. For example, thermal discomfort may lead to rushing, heat-induced fatigue, or mental distraction.
Extreme temperature is unevenly regulated in Canada. Some jurisdictions, such as Alberta and Ontario, have no OHS provisions addressing extreme heat or cold. Other provinces offer general duties to prevent thermal stress, while a minority of jurisdictions have adopted temperature limits established by external agencies. Gender-based job segregation can affect heat and cold exposures on worksites. For example, Karen Messing’s study of meat processing found that, while women did not work in the extreme cold of meat freezers, their work required them to stay relatively immobile at their work stations, where temperatures hovered around 4 degrees Celsius. Men in the study experienced significant lower temperatures working in the meat freezers, but their work was more active and the additional body heat generated by this activity attenuated the effects of the cold.

Temperature poses a unique OHS challenge in that it is often not possible for an employer to control the hazard at the source (since the weather is out of our control). The most effective control for preventing thermal stress is to limit workers’ exposure to hazardous temperatures. It can, however, be difficult to determine what temperature is too hot or cold for work to occur. There are many factors, including wind chill and humidity, individual temperature sensitivity, and the nature of the work being performed (light or heavy effort) that shape when a worker is at risk of thermal stress. Compounding these issues is that of variability. Weather conditions and work tasks change over time. This instability in working conditions requires closer monitoring of changes in the hazard than is the case with most other physical hazards.

The American Conference of Governmental Industrial Hygienists (ACGIH), an industry group of OHS professionals working in government, has established a matrix for determining when work should be reduced and, ultimately, ceased. For example, the ACGIH recommends that work cease completely at temperatures between −32 and −43 Celsius, depending on wind chill. On the warm end, the limits are more complicated due to humidity effects, but temperatures above 30 Celsius require work reduction or cessation. Within the recommended maximum and minimum, the degree of exposure is dependent upon clothing and other factors, such as access to fluids and rest breaks to warm/cool. Thus the need to establish controls extends beyond the extremes to ensure workers are shielded from the effect of hot or cold temperatures. Other controls include relocating work, installing heating/cooling devices, work-rest cycles, preventing working alone, and minimizing manual effort.
Radiation is any energy emitted from a source, including heat, light, X-rays, microwaves and other waves, and particles. Radiation is categorized into two forms: ionizing and non-ionizing. Ionizing radiation is radiation with enough strength to remove electrons from a molecule as it passes through. The electron loss causes the molecule to become positively charged (called an ion). Examples of ionizing radiation include X-rays, gamma rays, alpha particles, and neutrons. Non-ionizing radiation is unable to ionize molecules but may have other effects, and includes microwaves and radio waves as well as ultraviolet, visible, and infrared light.

Ionizing radiation can occur naturally at low levels from a variety of sources but is uncommon in workplaces. It is most often found in medical, nuclear, and research facilities. When ionizing radiation is present in a workplace, it poses a significant safety hazard. Both short exposures to high levels of radiation and long-term exposure to lower levels have serious health consequences. It is estimated that people are exposed to approximately 0.0125 rem (a standard measure of radiation) of naturally occurring radiation per year. Short-term exposure of 1000 rem will lead to death within a few days. An exposure as low as 10 rem will lead to a significant increase in the risk of cancer later in life.

Long-term, lower-level exposure is also a concern as it, too, can lead to increased risk of cancer. The recommended annual exposure for the general public is 0.1 rem. Nevertheless, the ACGIH recommends an annual limit for workers exposed to ionizing radiation to be 2 rem, a figure much higher than public health limits. Controls for ionizing radiation are quite expensive and technical, requiring significant engineering controls. Specialized training is also required, and exposure to ionizing radiation should never be taken lightly.

Box 4.4 The Elliot Lake strike and the origins of OHS

As we saw in Chapter 2, comprehensive injury-prevention legislation was only enacted in the late 20th century. One of the catalyzing events was an April 1974 wildcat strike by 1000 uranium miners from Elliot Lake, Ontario, that lasted three weeks. A wildcat strike is an unsanctioned, spontaneous strike by workers. The workers struck over high levels
of radiation exposure, and Elliot Lake was one of Canada’s first health- and safety-related walkouts.

Officials from the United Steelworkers of America (USWA), the union representing the workers, had just returned from a uranium safety symposium in France, where they became aware of a study by the Ontario Ministry of Health that showed Elliot Lake miners were three times more likely to die of lung cancer than the rest of the population. The culprit was radiation caused by the release of radioactive radon gas during uranium mining.

The news hit the workers like a bombshell. They did not even know the government was studying them. The workers walked out immediately after the union meeting where the study was revealed. For 10 days, the employer refused to even talk to the workers about the issue, and only agreed to negotiate around safety issues after the strikers refused to return to work.

The workers were particularly angry that both the employer and the government had long known the workers were being exposed to dangerous radon gas but had said and done nothing. As striker Ed Vance put it: “They deliberately kept us ignorant. There is no other way to describe it. Government has a responsibility and in this case they failed to keep the workers advised. They failed to warn the workers of their work environment. And, they were part of that conspiracy.”

The efforts of the Elliot Lake workers eventually resulted in changes to OHS rules. As for the employers, “[the mining companies] were brought in kicking and screaming” to protecting workers, says former miner and President of USWA, Leo Gerard. Elliot Lake revealed how employers’ economic interests combined with the state’s role in maintaining production (in this case, by supporting employers’ interests) can lead to the injury or death of workers.

The Elliot Lake strike, and other direct action taken by workers in defence of their health in the early 1970s, forced governments to do more to protect workers’ health. Within a few years, Ontario’s first Occupational Health and Safety Act was passed and more stringent controls placed upon radiation exposure and other hazards. Other jurisdictions soon followed suit (Saskatchewan actually passed Canada’s
first OHS act in 1972). The disturbing question that lingers is whether any of these legislative changes would have come about if the group of miners hadn’t decided they were no longer prepared to die because of their job.

Non-ionizing radiation, in comparison, has less dire health effects, but should not be ignored. Longer-wave non-ionizing radiation (such as microwaves) can cause deep tissue damage, cataracts and other eye issues, and skin rashes as well as interfere with the operation of pacemakers. Infrared radiation can lead to corneal and retinal burns and other eye injuries.

The most common non-ionizing radiation exposure is ultraviolet light (UV). UV radiation damages our skin, leading to burns and permanent skin darkening as well as heightened risk of skin cancer. It also damages our eyes and can cause pain and swelling in the eye and blurred vision, a condition variously called snowblindness, welder’s flash, or flash burn. The sun is the most common source of UV radiation, but UV radiation can also be produced by welding equipment, black light lamps, mercury lamps, counterfeit currency detectors, fluorescent tubes, and nail-curing lamps.

Controls for non-ionizing radiation should include replacing radiating equipment, proper maintenance to prevent fugitive radiation (such as with microwave ovens), separating workers from the radiation source, reducing exposure time to low levels, and using UV-blocking PPE (e.g., hats, clothing, sunscreen).

Box 4.5 Are cell phones a cancer risk?

Cell phones are ubiquitous in workplaces, in particular for white-collar occupations. There is an ongoing debate about whether cell-phone use increases a person’s risk of cancer. The main concern is that cell phones emit low-energy radio frequency radiation. It is known that low-energy radiation (such as microwaves) can cause molecules to heat up (which is how microwave ovens work). When a cell phone is used at someone’s ear, the radiation is quite strong near the brain, raising fears of possible risk of brain cancer.
To date, the risk posed by cell phones remains unclear. A number of large-scale studies have failed to find an overall link between cell phone use and cancer. These results have led some organizations, such as the US National Cancer Institute, supported by most governmental agencies, to downplay the risk. However, a number of studies have found possible links between heavy users of cell phones and increased cancer, as well as higher sensitivity to low-energy radiation among children. The International Agency for Research on Cancer (IARC), classifies cell phone radiation as “possibly carcinogenic to humans” (class 2B). Class 2B classification means the IARC feels there is “limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals.” In short, the IARC feels there is some evidence of a cancer risk but not enough to reach a definitive conclusion.

In contrast, in spring 2015, a group of 195 scientists from 39 countries released a joint letter to the United Nations declaring their position that electromagnetic field (EMF) radiation (of which cell phones are one source) poses a serious health risk to humans, including “increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans.”

The lack of clarity around the risk of cell phones points to the need for continued research to determine the effects of low-energy radiation. It also suggests a need for increased efforts to decrease the amounts of non-ionizing radiation emitted by cell phones and other devices, even before final conclusions have been drawn.

The current uncertainty over the hazard posed by cell phones (and other EMF sources such as video display terminals and WiFi) is an example of how technology moves much faster than our knowledge of its effects. It can be difficult to gather sufficient evidence to make a clear case (one way or another) in a short period of time, especially when dealing with diseases like cancer, which can have a latency period of decades.

Health agencies tend to be conservative in their recommendations regarding health risks. In the period between introduction of the
technology and a clear scientific outcome, workers can be left without adequate protection. Indeed, workers are often the first to exhibit health-related effects of new hazards because they are often the most intensively exposed. The case of cell phones highlights the importance of considering the precautionary principle when adopting new technology.

**ERGONOMICS**

*Ergonomics* is the study of how workers and the work environment interact. It is a broad-based approach to OHS that considers how the design of work affects the human body and its health. Ideally, ergonomics starts with job design. *Job design* comprises the decisions employers make about what tasks will be performed by workers and how that work will be performed.

Job design includes establishing the physical dimensions of work. This includes the size and location of the workspace, and what furniture, tools, and equipment will be used, as well as the temperature or lighting of the workspace. Job design also determines the nature of the tasks, including their complexity, pace, and duration and how individual tasks and jobs relate to one another. Finally, job design often includes making decisions and assumptions about the characteristics of the workers who will perform the work, including their height, weight, sex, and other physical and mental abilities.

The decisions made during job design can have significant effects on workers’ health and safety. Poor work design has negative effects on worker health. For example, if you have ever worked at a job where, at the end of the day, your eyes hurt (due to poor lighting) or your back was sore (because of standing on a cement floor), you have experienced ill health caused by poor ergonomics.

A core principle of ergonomics is “fit the job to the worker, not the worker to the job.” More specifically, ergonomics seeks to ensure that the design of work matches the anatomical, physiological, and psychological needs of the worker. Yet some ergonomic hazards are easier to “see” than others. For example, back pain from heavy lifting is easier to identify than fatigue due to poor shift rotation design. The broad acceptance of lifting as hazardous and requiring control shows that the relationship between the hazard and the injury is both
direct and well accepted. By contrast, there are many factors contributing to worker fatigue. This makes it difficult to definitively prove that shift rotation is an important factor in worker fatigue (or, as we’ll see in Chapter 5, cancer).

The aspects of ergonomics that have been more readily adopted are the design of tools, equipment, and workspaces. For example, we have seen an increase in more appropriately designed keyboards, work stations, retail scanners, and other equipment. There has also been greater attention paid to minimizing manual lifting and handling of loads. Buildings are being built with better climate and air-quality control.

Employers have been more reluctant to address other ergonomic issues because the required changes affect the work process or may impede management’s ability to direct work. For example, providing a better-designed chair to prevent spinal deterioration is easier and cheaper than altering the work flow to reduce the mechanical forces exerted on workers’ spines by twisting to reach objects. This reluctance to address some ergonomic hazards echoes employers’ preference for PPE over engineering and administrative changes that we saw in Chapter 3. As well, government OHS regulations tend to address only small pockets of ergonomics, such as manual lifting, while remaining silent on many other aspects.

A common health effect of poor ergonomic design is repetitive strain injury (RSI). As we saw in Chapter 1, RSIs (which are sometimes called cumulative trauma disorders) are injuries to muscles, nerves, tendons, or bones caused by repetitive movement, forceful exertions and overuse, vibration, and sustained or awkward positions. RSIs frequently occur in the hands, wrists, and arms but can also afflict legs and other key joints. Carpal tunnel syndrome, frozen shoulder, trigger finger, tendonitis, bursitis, and (more recently) Blackberry thumb are all examples of RSIs.

Any task that requires either the same movement over and over again or puts the body in an awkward position can lead to RSIs, especially if repeated over a long period of time. RSIs have only gained acceptance as the outcome of workplace hazards over the past 20 years. They were first acknowledged in factories with workers on assembly lines. Even today workers in some occupations, such as retail clerks, typists, and restaurant servers (notably occupations dominated by women), still have greater difficulty having RSI claims accepted. Among the reasons for the slow acceptance of RSIs is the murky causality of the disease: did you get it from keyboarding at work or playing squash on your own time? RSIs may also worsen even after the hazardous
tasks are eliminated and can appear as a result of work not normally associated with repetition. There has been inadequate epidemiological research into the full range of factors that lead to RSIs.29

Box 4.6 Two RSI examples

Meat-processing and cashier jobs are both associated with the development of RSIs. Meat-processing is a difficult job that involves heavy, dirty, and repetitive work. “Workers must repeat the same motions again and again throughout their shift. Making the same knife cut 10,000 times a day or lifting the same weight every few seconds can cause serious injuries to a person’s back, shoulders, or hands. Aside from a 15-minute rest break or two and a brief lunch, the work is unrelenting.”30 Cold temperatures (most of the work is performed in coolers to delay deterioration of the meat) compound the risk of injury. One study found that meatpacking workers are up to 80 times more likely to experience RSIs than other workers.31

In the past 20 years, RSIs have become widely acknowledged as a serious OHS issue in meat-processing plants. Facing significant economic pressure, meat processors have kept the speed of the production line high. They have also gotten rid of unions and shifted their hiring to more vulnerable immigrants and migrant workers. In short, employers have not controlled the hazards—they have just made it harder for workers to assert their safety rights. Not surprisingly, meat-processing workers frequently have difficulty having their RSIs accepted as “real” injuries and the hazards posed by the work process controlled.

Ana Ramos came from El Salvador and went to work at the same IBP plant as Albertina Rios, trimming hair from the meat with scissors. Her fingers began to lock up; her hands began to swell; she developed shoulder problems from carrying 30- to 60-pound boxes. She recalls going to see the company doctor and describing the pain, only to be told the problem was in her mind. She would leave the appointments crying. In January 1999, Ramos had three operations on the same day—one on her
shoulder, another on her elbow, another on her hand. A week later, the doctor sent her back to work.32

Being a grocery clerk—moving small items across a scanner and bagging them—may not seem like physically demanding work. Over the course of a shift, however, a clerk can be required to lift more than 2000 kg of groceries. The lifting is in thousands of swipes of mostly small packages. The repetition, combined with twisting and awkward positioning as well as standing for long periods, make grocery clerks highly susceptible to RSIs.

Mary Ann Anderson has been a cashier at a grocery in Queens for about 12 years. With a remodeling about two years ago, the store replaced old-style cash registers with price scanners at the checkout stands. That’s when Anderson’s pain began. She noticed the scanner made her do more pulling, lifting and twisting of her wrist—she held each item at an angle so the scanner could read the price code. Also, Anderson and others found that taller clerks handled the raised weight scales and register tapes better than shorter clerks, but the shorter clerks were more comfortable with the scanner height. And nothing was adjustable. Last year the tendinitis in Anderson’s arms and wrists forced her to miss more than two months’ work.33

The part-time, gendered nature of retail work has made it more difficult to get retail-related RSIs recognized. Employers are reluctant to make substantial design changes to checkout stalls, as they are designed for consumer, rather than worker, convenience. It is easier to replace the workers when they “wear out.”

Engineering controls are the best way to address ergonomic hazards. Wrist supports, rest breaks, and other controls-at-the-worker fail to address the root cause of the hazard and do not effectively prevent the onset of injury. Ergonomic principles require that the design of the work be altered to better fit the needs of the workers in question. What those specific controls look like is highly dependent upon the nature of the work and the demographics of the worker.
SUMMARY

Returning to our opening vignette, the owner of Metron Construction, scaffold supplier Swing N Scaff, and project manager Vadim Kazenelson were all convicted of offences after the Toronto scaffolding collapse. Metron was fined $750,000 for offences under the Ontario OHS Act. Swing N Scaff was ordered to pay $400,000, also under the OHS Act. In June 2015, Kazenelson was convicted under the Criminal Code for criminal negligence causing death and criminal negligence causing bodily harm. He was sentenced to 3½ years in prison. At the time of writing, both his conviction and his sentence are under appeal. As we saw in Chapter 2, criminal prosecution is rare in Canada (there have been fewer than 10 since the Westray amendments were enacted in 2004) and so Kazenelson’s conviction is noteworthy.

These convictions may have brought some solace to the families of the four killed workers. Yet, given the number of annual injuries in Canadian workplaces, clearly many hazards—including obvious physical hazards—remain uncontrolled in Canadian workplaces. While this situation may, in part, reflect the fact that some hazards are difficult to identify and control, we also need to be cognizant that employers often have a financial incentive to cut corners on safety.

DISCUSSION QUESTIONS

› Why are some physical agents difficult to identify?
› How are noise hazards identified and what are the shortcomings of current approaches to controlling it?
› Why might vibration and noise exposure appear together?
› What are the effects of thermal stress and how can they be prevented?
› How are ionizing and non-ionizing radiation different and in what ways are they both hazards?
› What is the core principle of ergonomics and why have OHS practitioners been slow to adopt it?
EXERCISE

Select a workplace for consideration. It can be your workplace or a workplace you are familiar with. Complete the following steps:

1. Identify three physical hazards present in the workplace.
2. Using the process in Chapter 3, assess the risk and prioritize the three hazards.
3. Identify engineering, administrative, and PPE controls that would eliminate or reduce the hazards.
4. Discuss the pros and cons of each control from both a worker and employer perspective.

NOTES

5 Barnetson, B., & Foster, J. (2015). If it bleeds it leads.
6 AWCBC. (2014).


Based on Alberta Occupational Health and Safety Code, Schedule 3, Table 1.


