Losing grip

Experts warn about the little-known adverse effects of occupational vibration exposure for mining workers

By Sarah St-Pierre

Courtesy of CROSH

Dawson O'Hara, a master's student at the Centre for Research in Occupational Safety and Health at Laurentian University, taking foot-transmitted vibration measurements underground.

Katie Goggins conducts workshops for mining workers to raise awareness about the health risks of occupational vibration exposure. Most of the time, workers who attend her sessions have little prior knowledge about the conditions associated with it. Yet, by the time she is done with her presentations, she often hears them say, "Oh my God, I have that."

Occupational hazards are a dime a dozen for mining workers—and robust safety standards have helped to preserve their health. Vibration-induced health problems, however, remain among the least understood and least widely prevented risks.

"Vibration is typically an afterthought," said Goggins, a senior scientist at the Centre for Research in Occupational Safety and Health (CROSH) at Laurentian University in Sudbury.

Experts, however, are unanimous: the damage occupational vibration exposure can cause is not trivial. Such exposure is not restricted to the mining industry, but it is one of the most at-risk sectors, especially in hard-rock mining. Prevention and awareness are the keys to limiting the harmful impacts of vibration exposure, and new research will be key to help workers avoid permanent injuries.

The anatomy of exposure

Prolonged exposure to vibration from equipment or machinery can create different risks for mining workers. For example, those who spend long shifts sitting in a vehicle cab may be exposed to whole-body vibration (WBV), which can disturb the spine and lead to musculoskeletal disorders.

"It also increases the load on the muscles," said Pierre Marcotte, a noise and vibration researcher at the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) in Montreal, who has a background in engineering physics and mechanical engineering. While exposed to vibration, the back muscles work to try to stabilize the spine, he explained.

Beyond lower-back and neck pain, WBV may cause other conditions, although the evidence for them is not as well established as the evidence for back and neck problems. These conditions include elevated stress levels, digestive problems, insomnia, headaches, dizziness, motion sickness and decreased cognitive function.

There are also different types of segmental vibration exposure, which primarily affect the parts of the body that are in contact with the vibrating equipment or machinery.

For example, hand-arm vibration syndrome (HAVS) is a condition associated with damage in the hands, arms and fingers that is largely incurred through the manipulation of handheld power tools. It is currently the most researched and best understood of the types of vibration exposure.

Foot-transmitted vibration (FTV) is often lumped into studies on WBV, rather than having its own dedicated research to determine effects on the feet and toes. Workers who spend time standing on vibrating platforms are the most at risk. Out of the three types of exposures, it is the least commonly recognized and the least studied. "It's in its infancy as far as vibration research goes," Goggins said.

All pain, no play

Because the health effects of occupational vibration exposure are not instantaneous, with the related conditions progressing slowly over months or even years, Marcotte said that people do not always make the connection between the symptoms they are experiencing and vibration exposure. Many conditions cause similar symptoms, so a diagnosis is largely a matter of ruling everything else out. The tests, altogether, take several hours to conduct.

When vibration is transmitted to the hands, it can damage soft tissue and the small nerve endings in the fingers and palms. Numbness, tingling and even decreased motor function can result from the neurological damage incurred. Carpal tunnel syndrome can also develop from hand-arm vibration exposure. If vibration exposure results in damage to the muscles, joints and bones, the hand's grip strength can degrade.

If the blood vessels are damaged, they may spasm and the fingers may turn white from exposure to the cold—a condition known as vibration white finger (VWF), sometimes referred to as "Raynaud's phenomenon of occupational origin." At first, only the tips of the fingers may experience the blanching attacks, but if exposure goes on, VWF can creep farther up the digits.

Workers exposed to FTV may see the same symptoms in their toes. According to Goggins, the blanching and numbness experienced in the toes can be mistaken for frostbite and only noticed back at home when workers take off their boots.

Exactly when exposed workers start to exhibit symptoms, as well as which of those symptoms they experience, relates to the intensity and frequency of their vibration exposure over time. People with high exposure may start to show symptoms after a few days or a couple of years, making the risk a concern for workers young and old.

Dr. Ron House works with HAVS patients through the Centre for Research Expertise in Occupational Disease (CREOD) at St. Michael's Hospital in Toronto. "We do see some younger people with the condition in mining, especially in some of the smaller mines where there's perhaps fewer controls in place," he said. However, most of his patients are at least 35 to 40 years old.

The good news for workers experiencing early symptoms of HAVS is that at first, they may be transient and reversible. However, if vibration exposure continues, nerve and vascular damage can worsen to the point of permanence. In the very worst cases, HAVS can lead to the amputation of fingers if gangrene develops.

HAVS also makes fine motor activities that involve the hands and fingers more difficult to perform. Once vascular damage has set in, simply being outside in the cold aggravates the HAVS symptoms and activities become more challenging, whether they are related to work or not.

House sees a lot of patients from northern Ontario, many of whom are miners. "A lot of them like ice fishing and snowmobiling, outdoor winter activities, and those things become very difficult as they get older and HAVS progresses," he said.

Family doctors and compensation boards refer workers exhibiting HAVS symptoms to specialists like House, whose clinic at St. Michael's conducts an average of 200 assessments a year. The patients tend to reflect the demographics of the mining industry. "The majority of the patients that we see are men, but we do see some women; including, now, younger women," House said.

He believes HAVS is under-recognized and underdiagnosed across Canada. "Many workers would not come to medical attention or have a compensation claim submitted until they had much more severe symptoms," he added.

Prioritizing prevention

Experts and physicians would rather see patients who are only just starting to experience symptoms of vibration-related health conditions. At that point, it is easier to make sure permanent damage will not set in.

Canada does not have formal regulations limiting occupational vibration exposure. According to the Canadian Centre for Occupational Health and Safety in Hamilton, many Canadian jurisdictions have no specific regulations for it, while others follow standards set by foreign agencies, like the threshold limit values suggested by the American Conference of Governmental Industrial Hygienists.

Marcotte believes that further regulations would be helpful, but his priorities currently lie elsewhere. "For me, what is even more important than regulation is making people aware," he said.

Awareness, in this case, goes hand in hand with preventing harm. For Goggins, because the exposure is so high for mining workers, focusing on prevention in the industry is especially crucial.

Purchasing tools with lower vibration intensities can be a preventive measure. Personal protective equipment (PPE) that aims to reduce exposure to vibration exists, but according to House, it is not the most effective. Anti-vibration gloves, for example, even when tested and certified, will not entirely protect against very high-intensity vibrations, he said. They will degrade over time, needing to be replaced periodically depending on use. For frequent usage with high exposure to vibration, such PPE may need to be replaced as frequently as every few months, House added.

If workers are concerned about their exposure to vibration, House suggests reaching out to their employer, health and safety committee, or, if applicable, their union representative.

Administrative controls like limited exposure time and equipment purchasing policies that favour low-vibration tools, especially when replacing older ones, can be effective prevention measures.

For example, jackleg drills, which can drill into rock, have been common culprits in HAVS cases. According to Marcotte, using a jackleg drill would put people over the maximum daily exposure to vibration in less than half an hour. For this reason, they have become less widely used in the mining industry.

Research horizons

The move away from jackleg drills has come with complications of its own. Some have been replaced by vibrating platforms with boom arms, shifting the exposure type from the hands to the feet rather than eradicating it. This is a research focus for Goggins, who has been studying FTV since her master's degree, and it was the sole focus of the PhD that she completed in 2019; this type of exposure does not yet have its own standards governing safe exposure limits due to a lack of epidemiological studies, she noted. "We're working towards that at CROSH and with the ISO committee on human exposure to mechanical vibration and shock," she said.

Meanwhile, at IRSST, Marcotte is researching suspension seats to isolate workers from the effects of whole-body vibration in vehicles. Available international standards to evaluate suspension seats to reduce exposure to vibration address only vertical vibration, but bringing a vehicle off-road can create vibrations in all directions. When people ask for recommendations on which seat to buy for mining equipment such as trucks, the limited amount of information currently available about what is on the market can make it difficult to answer. The aim of the research, he said, is to "eventually help design a better seat, and also to help people choose a seat well-adapted to the vehicle."

House and his team at CREOD are in the process of publishing a paper on the effects of HAVS on the mental health of workers. "It's impacting their ability to work and make money, but also all other aspects of their lives," he said. The toll can become significant—the results indicate that workers with HAVS have poorer mental health than the general population, he noted.

House regularly enlists some of his patients to participate in research. Working in a specialized clinic that sees many patients affected by occupational vibration exposure has been a boon to his team, and he and his colleagues rarely have trouble convincing patients to sign up as research participants.

"I and the other people who work with me in the clinic say the same thing," House said. "These patients are very decent, hard-working people who have developed this problem, and they're very keen on getting to the bottom of it." CIM

Courtesy of WSP

WSP's Courtney Gendron on site doing an occupational exposure assessment.

Protecting women's reproductive health

As more women enter the mining industry, better strategies are needed to protect them from reproductive hazards in the workplace

By Dinah Zeldin

When Nancy Wilk became pregnant in 1989, she was concerned about exposures to reproductive hazards in the workplaces she visited as part of her role as an inspector for Ontario's Ministry of Labour, including visits to mines and mineral processing facilities.

Her then-supervisor advised her to conduct her own research, such as making a list of teratogens—agents or factors that can affect the development of a fetus—which they would follow up with a discussion about reproductive hazards and potential accommodations. "As an occupational hygienist, I had the knowledge to [ask the right questions], and my needs were accommodated," Wilk explained. However, not everyone has her knowledge and experience about the potential risks.

Today, Wilk plays a leading role in helping ensure the health and well-being of mining workers as a senior technical director of environmental, health and safety (EHS) and industrial

hygiene with WSP, and advocates for more research to support best practices in her field as president of the International Occupational Hygiene Association.

In her opinion, not enough has changed in the intervening decades. While there have been improvements from a regulatory perspective, with jurisdictions across the country enshrining rights such as protective reassignment (moving a person to another role to protect them from workplace health and safety risks) for pregnant workers, mining companies often lack the knowledge to provide optimal support.

Barriers to research

According to Wilk, women in mining face multiple barriers to accessing workplace health support tailored to their needs. For instance, fly-in-fly-out sites are often not equipped to provide adequate health care.

"We are aware of a situation where a woman at site had a miscarriage, and the site was not prepared to respond," she recounted. "She had to be airlifted out, which added to [her] embarrassment and discomfort."

However, mining companies are beginning to take note: Wilk and her colleague Courtney Gendron, senior occupational hygienist with WSP, have presented to mining companies' occupational health and safety teams and have done reproductive hazard assessments at mine sites. The latter is where they encounter a challenge.

"The biggest issue around health and well-being of women in mining, and their reproductive health, is that there is a dearth of research, standards and guidance," Wilk explained.

According to Wilk, the main reason for this lack of information is that the majority of occupational health research is based on a "reference man," who is 25 to 30 years old, Caucasian, weighs 70 kilograms and is free of chronic disease.

One way that researchers should address this disparity in future research, she suggested, is by disaggregating data by sex, and including a representative percentage of women when possible. Although, she pointed out, this would still fail to account for the health of the fetus.

Sandra Dorman, director of the Centre for Research in Occupational Safety and Health (CROSH) at Laurentian University in Sudbury, noted the challenges of conducting original research in this space. Being a niche topic makes it difficult to access funding or find a representative sample size—women represented just 16.8 per cent of Canada's mining workforce in 2023, according to Mining Industry Human Resources Council data—and it is also a sensitive area.

"Most of the work that has given us good guidance on what a clear hazard is during pregnancy is available because there was a group of women within a community that were all exposed to the same thing, and a problem was noticed," she explained.

"Nobody will do a study to look at what diesel exposure does to a pregnancy [as it would be unethical], but we can look at community data from communities that have high diesel exhaust exposures and monitor their pregnancy outcomes."

Ongoing efforts

In 2012, Dorman was approached by Ontario-based not-for-profit organization Workplace Safety North to be the lead author on a guide about reproductive hazards in mining.

Dorman and her team conducted a comprehensive literature review, consulting English-language papers from around the world, and distilled the information to identify reproductive hazards, provide a description of the risks to the mother, the fetus and/or the breastfeeding child, and suggest actions to avoid the risks and provide appropriate accommodations.

The *Guide to Healthy Pregnancies in the Mining Workplace*, which was distributed to mining companies and made available on CROSH's website, continues to be a leading resource on reproductive hazards in mining.

"It gained popularity because as more women continued to be hired in mining, people were getting pregnant and asking the health and safety representatives at their sites what they should be doing, and those people could not find a lot of answers," Dorman said.

In her practice at WSP, Wilk relies on several sources to ensure her recommendations are as comprehensive as possible when conducting assessments for reproductive hazards at a site. Alongside Dorman's guide, she looks at a table of exposure limits from WorkSafeBC, which provides an extensive list of reproductive toxins and exposure limits derived from publications by the American Conference of Governmental Industrial Hygienists. She also consults publications by the U.S. National Institute for Occupational Safety and Health.

Wilk strives to identify ways to support pregnant women without resorting to protective reassignment, while ensuring that risks are as low as reasonably achievable. "It is always preferable, when possible, to keep them safe within their position, because when you are transitioning someone [to a different role], you are moving them to a different team and a different culture, and they are having to learn something new," she explained. "Besides, they might really enjoy their job."

Common reproductive hazards

Based on their experience, Wilk and Gendron have identified eight reproductive hazards as being the most commonly encountered by mining workers.

Noise

Noise levels above 85 dBA (A-weighted decibels, a unit to measure the relative loudness of sounds as perceived by the human ear) are associated with increased stress to the mother and the fetus, which can contribute to low birth weight, preterm delivery and hypertension for the mother. Pregnant women are advised to use adequate ear protection and avoid noisy areas whenever possible.

To protect the fetus from hearing impairment, from the fifth month of pregnancy onwards, continuous exposure (more than eight hours) of the abdomen of a pregnant worker to noise at 115 dBC (C-weighted decibels, a unit to measure peak noise and short, instantaneous impact noise) should be avoided, and peak exposure to noise at 155 dBC or above.

Heat

Heat exposure (see p. 33) can have detrimental effects for both the mother and the fetus, and may impact breastfeeding. Pregnant women are advised to avoid environmental temperatures above 32 degrees Celsius (especially in the first trimester), to increase water consumption by two cups above pre-pregnancy amounts, to wear monitoring devices for core temperature (which should remain below 38 degrees Celsius)

and heart rate (which should remain below 160 beats per minute) and to elevate their legs during breaks.

Vibration

Whole-body vibration (WBV) (see p. 28) increases risks of miscarriage and pre-term delivery and may increase risks of pre-eclampsia and other adverse health effects for the mother. There are no regulated exposure limits for WBV in Canada and specifically no data on safe exposure limits for the pregnant worker. Pregnant women are advised to avoid exposure to vibrations at resonance frequencies of the spine (10 to 12 hertz) and of the uterus (eight hertz).

Ionizing radiation

Exposure to ionizing radiation is common in mines, especially in those with thorium or uranium deposits, and is established as a potential cause for multiple serious issues with fetal development. In Canada, the legal dose limit after pregnancy disclosure is four millisieverts for the duration of the pregnancy, and certain jurisdictions have additional regulations. Controls involve monitoring the dose received, as well as minimizing exposure to as low as reasonably achievable (ALARA) by restricting time, increasing distance and using shielding, as necessary.

Toxic metals

The most common toxic metals exposure in mining comes from lead, which is encountered in fire assay labs, in ore or waste rock, or if it is the commodity being mined. Lead is known to cross the placenta and affect the fetus, can cause hypertension in the mother and can be excreted in breast milk.

There are no set lead exposure standards for pregnant workers, so women are advised to keep exposures as low as possible while pregnant and breastfeeding. The Ontario Ministry of Labour, Immigration, Training and Skills Development provides a few values that include specific review and removal criteria for pregnant women and women of child-bearing potential, which Wilk advises be used as best practice across the country.

Other metals of high concern include cadmium, chromium and mercury, which also have no set exposure standards for pregnant workers. Wilk recommends removal from potential exposure.

Ergonomic hazards

Lifting, pushing, pulling, bending and sustained postures can have an array of effects on both the mother and the fetus. These can range from muscle strain, back pain and fatigue for the mother to an increased risk of spontaneous abortion, low birth weight and pre-term delivery for the fetus. "[During pregnancy] ligaments relax, the centre of gravity changes and general movement is more difficult," explained Wilk.

She recommends controls be implemented based on a woman's health history as some need more accommodations, and to be adjusted as the pregnancy progresses.

Scheduling

Extended shifts and overnight work can increase risks of spontaneous abortion, low birth weight, pre-term delivery and sleep disturbances for the mother. Scheduling accommodations also need to be made to ensure breastfeeding women are able to express milk.

Wilk recommends avoiding night shifts, as well as restricting the number of hours worked and the window of hours during which work occurs, but encourages employers to actively engage women in any scheduling decisions as every worker experiences fatigue and stress in a different way.

Stress

Stress can affect a pregnancy, potentially leading to pre-term delivery or low birth weight. Being pregnant in a male-dominated workplace can be stressful. Wilk advises that mining companies focus on education, awareness-building and site preparation to help pregnant women feel more at ease. A workplace health and safety culture where early disclosure of pregnancy is supported, and a site where health facilities are able to support women going through a miscarriage or experiencing early labour, play an important role.

Looking to the future

Dorman feels mining companies could do more to support pregnant workers. "For now, it's mostly about education within the workplace," she said. "Leaders who are really passionate about health and safety can help drive that change."

For Dorman, the key to mitigating reproductive hazards for women in the workplace is simple. "People get especially nervous about some of the chemicals," she said. "But I think addressing the broader effects that are hurting everybody, like exposure to carbon monoxide from diesel exhaust, will go a long way. As long as you are reducing hazards to everybody, you are reducing hazards to women across the reproductive health cycle."

From a research perspective, Dorman said there are opportunities for mining companies to step up—by collecting data and conducting monitoring internally, and by funding research.

For physical and chemical hazards, she recommends closer monitoring of baseline exposure. "For carbon monoxide, you could do a breath test daily, and if you saw your level went up during pregnancy, you could make a modification based on that knowledge," she explained. "There are a number of hazards you could do the same thing with through regular blood testing."

Dorman also suggested that an investment in qualitative research would help mining leaders to better identify potential reproductive hazards. "If a number of women were identifying the same concerns and we were documenting it, we would be getting valuable information," she pointed out.

In the meantime, Dorman plans to update her guide to make it more accessible to mining workers and to translate it into French.

For her part, Wilk remains dedicated to advocating for more original research and industry support for pregnant women in mining. "I regularly meet with occupational health professionals in mining, as a mentor, and we discuss this," she said. "Items have yet to be actioned. An approach like this needs to be driven by leadership at a very high level."

Wilk also shares her message by presenting to global mining companies.

"All of us have a responsibility to create inclusive and safe cultures. Until this happens, there will be low participation and low retention of women in mining," she concluded. CIM

Courtesy of Emily Tetzlaff

In the heat of the mine

Wenco's Emily Tetzlaff discusses why heat management programs are increasingly important to protect the health and safety of mine workers

By Ailbhe Goodbody

Emily Tetzlaff is a recent PhD graduate of the human kinetics program from the Human and Environmental Physiology Research Unit at the University of Ottawa. Through her doctorate, she was also a research affiliate with the Climate Change and Innovation Bureau at Health Canada, and a fatigue risk management analyst for Torex Gold Resources Inc.

Since Tetzlaff entered the mining industry in 2015 as a researcher and corporate health promotion specialist, she has published more than 30 peer-reviewed publications and now holds the title of principal scientist, environmental, health and safety (EHS), for Wenco International Mining Systems. *CIM Magazine* talked to Tetzlaff to learn more about the dangers of heat stress in mining environments and a proposed worker heat protection standard that is currently being considered in Ontario.

CIM: Why are occupational heat management programs important at mining operations?

Tetzlaff: The mining industry has multiple work environments—underground operations, open pits, smelters, mills, exploration sites—that all have a unique context when it comes to heat stress. But there are three key aspects to understanding the complexity of heat stress in mining: environmental factors, metabolic heat and clothing requirements.

Environmental factors include heat, humidity, air flow and radiant sources of heat at the site. Underground sites have high heat loads from the geothermal gradient [the climb in temperature with increased underground depth], heat generated by auto compression [a temperature increase caused by elevated air pressure at depth], heat from groundwater in the mine headings, and heat generated by blasting. There is also a massive push right now for mining at depth and going even deeper on existing sites, which exacerbates the heat load.

In surface mining, anyone working in open pits has radiant exposure from the sun. If you're working at a plant, a refinery or a mill, there is lots of radiant heat coming off of different mechanized equipment.

The mining industry also has a lot of confined space work in mills and smelters, as well as underground. These environments are challenging because if we don't have air passing sweat on the skin's surface, we don't have a cooling effect.

The second factor to consider is the metabolic heat that a person generates, which is related to their workload. Despite lots of movement towards automated equipment and remote work in the mining industry, there's still a requirement for moderate to very heavy work being performed. That is going to generate heat inside the person's body and it can pose a substantial compounding risk as well.

The third aspect is the clothing requirements. The mining industry has extremely rigorous standards for personal protective equipment (PPE) to protect workers from other critical hazards. Because of that, they're often working in an uncompensable environment—[meaning] there are challenges to their ability to sweat or vasodilate, so they are unable to dissipate heat into their work environment.

In the smelter, for example, we've got individuals working at the furnace in aluminized garments, and others loading acid into train cars in Tyvek suits in the heat of summer. Those are two examples of the required PPE garments that are entirely

uncompensable, so those workers are at an extreme risk of heat strain when they're operating.

Because of how unique the work environments, workloads and PPE are in mining—a lot of the standard heat management controls that are used in, say, a factory or a smaller entity, like ventilation or site-wide air conditioning, are not necessarily feasible, cost effective or practical in many mining environments—this means that the industry is at a disadvantage for some of the primary control measures for heat stress.

CIM: What are some of the adverse effects of heat stress?

Tetzlaff: The difference between heat stress and heat strain is important. Heat stress is the heat load that workers are exposed to, while heat strain is the physiological response to heat stress; when we can't cope with that stress, we can experience a heat-related illness.

Heat-related illnesses exist on a continuum. So, the physical effects could be mild, like heat-induced fatigue or a heat rash. They could be heat syncope (fainting) or heat edema (swelling in the hands or feet). But they can also be moderate or severe, such as heat exhaustion and heatstroke. Heatstroke can be a fatal outcome for some people if it is not treated as an emergency.

There can also be acute psychological or cognitive effects from the heat, such as slower reaction times, a decrement to our ability to think critically or a lower awareness of our environment. This is key because mining environments can change rapidly, so if we're not aware of our surroundings—for example, if there's mobile equipment coming towards us—heat stress is now posing a safety hazard, as well as a health hazard.

There are also chronic outcomes that can happen from repeat exposure to the heat or having experienced multiple heat-related illnesses. That could be something like acute kidney injury—micro damages can happen at the cellular level over time—which can become chronic kidney disease, and that can lead to end-stage renal failure. There are potential chronic outcomes to the entire cardiovascular system, to the liver—all of our end organ systems can be impacted over time.

CIM: What signs or symptoms should people be aware of?

Tetzlaff: For heat exhaustion, you're looking for signs like feeling nauseous, or a heat rash. You might feel very thirsty, have a dry mouth or have difficulty swallowing. Your body temperature is probably around 38 degrees Celsius. You might be starting to feel light-headed, have very low or no urine output, and there could be challenges with your breathing. At this point, you likely have excessive sweating—I emphasize that one, because that's one of the transition symptoms that we see when we move from heat exhaustion towards heatstroke.

Signs of heatstroke are not just nausea, but actual vomiting; not just low urine, but no or extremely dark urine. Body temperature is now typically over 39 degrees Celsius, and you are likely no longer producing sweat because your body has become dehydrated. Sweating is our primary method for cooling the body, so if you lose that, your body temperature will continue to increase. You might have muscle cramps and spasms, a change in your comprehension and perhaps become a little erratic with your behaviour. As heatstroke progresses, you could become disoriented, faint or lose consciousness. At that point, you need to go to the hospital, as heatstroke can hit a critical point.

A big piece to highlight here is the importance of looking out for your colleagues, because often when you start to experience a heat-related illness, you've already lost some cognition and are not as aware of what's happening. So you need others to potentially step in and help each other.

CIM: What are the current regulations for heat management at mining operations?

Tetzlaff: We are at a very big transition point right now with policy reform; there is a huge movement, both in Canada as well as globally, for safety authorities to move towards acts and regulations that require companies to have heat management plans enacted with full requirements for training, reporting and all of the hazard controls to be in place. In Canada, there are different jurisdictions when it comes to safety—the federal authority (the Canada Labour Code), and then every province and territory has different legislation. The push for policy reform is a great step, but there are some gaps that need to be addressed in order to translate these new or proposed regulations to make them applicable to mining.

I will give Ontario's Bill 222 as an example, as we have many underground operations there and it will impact them pretty substantially. Bill 222 is an amendment to the Occupational Health and Safety Act in Ontario that will develop a worker heat protection standard; it was proposed in fall 2023, and the provincial government released the bill in November 2024.

Unfortunately, like a lot of heat management guidelines globally, the worker heat protection standard heavily references the American Conference of Governmental Industrial Hygienists heat stress guidelines, which were not formulated for the mining environment. For example, most mine sites are operating on 10- to 12-hour shifts and don't follow a standard five-day work week. This poses a challenge to complying with the current guidance.

On top of that, it doesn't necessarily protect all workers, because the guidance is founded off data that only included healthy young males that had no chronic disease and were not on any medication. This means that the mining industry's female workers, workers over the age of 65 or anybody with diabetes, hypertension or other comorbidity that relates to heat stress and impaired thermoregulation is at greater risk and might not be protected by current guidelines.

We also have massive under-reporting of heat-related illnesses in the Canadian mining industry. We've seen that in some of the work that I've led in the last couple of years, where people stated that they've had signs and symptoms while performing typical mining-related tasks, but they didn't report it. Some of it is due to rapid recovery; often, people don't report heat-related illnesses when they recover quickly, but if they did, we would see that there are many incidents happening.

Without that data and evidence, it becomes really challenging to say that we need more time, more resources, better controls or better administration of the work-to-rest regimes within a company.

We also need to have the proper education and training for the health and safety personnel at operations across Canada, so that they can respond to new regulations and develop strong protocols. This necessitates greater communication between industry representation and researchers to address this.

CIM: How can mining companies minimize and manage their workers' exposure to heat?

Tetzlaff: It is important to understand heat vulnerability and what it actually means. Just like heat stress, heat vulnerability

has three core factors that heat management programs need to look at: exposure, sensitivity and adaptive capacity.

Exposure, or how often a person is exposed to heat stress, is critical. How long are they in the heat? How frequent is that rotation? Is this a task they do for 30 minutes once a month, or do they have 12 hours of exposure every single day, every single shift? This matters for acclimation to the environment, which is a critical function that our body does to help get us used to the heat so that we can adapt and thermoregulate correctly.

The second thing is sensitivity, which refers to inherent factors such as sex; females have about a five per cent lower heat loss capacity than their male counterparts. People who are pregnant (see p. 30) have a lower capacity as well, as do those with chronic conditions and those on [certain] medications. Heat management can't just be one size fits all, but must be a little bit tailored to the individual worker.

But the third factor, which is very important for mining companies to consider, is adaptive capacity. In the mining context, this would refer to things like if a worker has autonomy to take action to protect themselves—if their company or supervisors would be okay with them taking a break from the heat if they need to, or if they can employ self-pacing to lower their metabolic load and stay within a safe limit. There is still some pretty big incentive-based programming within the mining industry. If there is a push to go farther or faster or produce more, then we typically don't self-pace adequately, and we don't apply things like a work-to-rest regime that's designed to help keep the body temperature within a safe limit.

Access to reprieve is also important. If you're underground, how close are you to your refuge station and does it have cooling, or are you in an area where you're taking your lunch while still in the high heat?

Companies looking to help minimize and manage their workers' exposure to heat stress have to critically consider these factors.

CIM: Are workers required to tell their workplace if they have a health condition or take medication that can affect their capacity to deal with heat?

Tetzlaff: This is a conversation we've had with different union representatives, because, of course, workers should have full control of what health conditions and medications they disclose to their employer. That being said, it is hard for an organization to help protect against vulnerabilities they aren't aware of.

I believe that training is a huge part of the solution to this challenge. Work sites should be providing heat-related training to their employees, which should include education on these comorbidities so that a person can have autonomy to then make their own decisions.

For example, if I'm pregnant and working in the mining industry and I receive heat-related training and see that working in the heat could place me and potentially the fetus at greater risk, I can then make a choice to go to my occupational nurse or HR rep and put a plan in place. If you don't know that you're at greater risk, you are at a disadvantage.

Similarly, the training should discuss medications that change how your body thermoregulates—certain antidepressants are a good example of this.

CIM: What would you recommend for companies that want to improve their heat management program?

Tetzlaff: Heat stress is a complex challenge with many nuances. Because of that, I think that it's often viewed as an unmanageable challenge, but it is not. There are very small steps that can be taken towards building up a heat management program, and there are good researchers across Canada who are dedicated to working on this problem and can act as a resource to help. I would encourage people to reach out to these researchers to get support in tailoring [a program] to their individual workplace. CIM