Work, Health and Wellbeing in the Construction Industry

Helen Lingard and Michelle Turner

WORK, HEALTH AND WELLBEING IN THE CONSTRUCTION INDUSTRY

This book covers a wide range of topics relating to the health and wellbeing of the construction workforce. Based on more than two decades of work examining various aspects of workers' health and wellbeing, the book addresses a key topic in construction management: how the design of work environments, construction processes and organisation of work impact upon construction workers' physical and psychological health.

Occupational health is a significant problem for the construction industry. However, the subject of health does not receive as much attention in occupational health and safety research or practice as the subject of safety. Traditional management approaches (focused on the prevention of accidents and injuries) are arguably ill-suited to addressing issues of workers' health and wellbeing. This book seeks to explain how workers' health and wellbeing are impacted by working in the construction industry, and suggest ways in which organisations (and decision makers within them) can positively shape workplaces and practices in ways that better support construction workers to maintain healthy and productive working lives.

Including chapter summaries and discussion questions to encourage student readers to reflect on and formulate their own viewpoints about the issues raised in each chapter, the book has the potential to be used as a textbook in undergraduate or postgraduate occupational health and safety, or construction management courses dealing with occupational health and safety. It could also be used as supplementary recommended reading in undergraduate or postgraduate programmes in architecture, engineering or management.

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PREFACE

In writing this book we sought to tie together a body of work undertaken over a period spanning 20 years. Some of this work has been undertaken individually but much of it we have conducted jointly. We felt it was timely and important to collate this work as construction workers' health is increasingly recognised as a neglected aspect of management practice in the construction industry (particularly when compared to the management of occupational safety). Construction workers are exposed to a wide variety of health risks in their daily work, including a vast array of chemical, physical and psychosocial hazards. Again, compared with safety hazards, many health hazards experienced by construction workers are not well understood or effectively controlled. Construction workers are also a high-risk group for suicide, with shocking statistics around this being reported in many countries of the world. There is a growing emphasis on the broader concept of workers' wellbeing, of which health is a part. This reflects a desire to ensure that workers are able to live and work in ways that enable them to remain physically, mentally, emotionally and socially well. Thinking about the long hours and weekend work that typically prevents project-based construction workers from engaging satisfactorily in life outside work, construction workers' wellbeing may seem to be an improbable prospect.

We wanted this book to challenge readers to think more deeply about the factors contributing to poor health in the construction workforce. In particular, we drew on the social determinants and social ecological models of health to position construction workers' health within the broader industrial systems within which construction projects are planned, procured and delivered.

As we have written this book, our understanding of the relationship between occupational and public health domains has evolved. This was, in part, due to the COVID-19 pandemic that placed workers' health in sharp relief. During the pandemic, the management of workers' health became critical for many construction organisations as the case for business continuity was predicated on the industry's ability to control the risk of COVID transmission. The stress caused by the global pandemic, lockdowns and other containment measures also highlighted the importance of supporting workers' mental health during this time.

As John F. Kennedy famously observed, crises bring with them both danger and opportunity. It is possible that the COVID-19 pandemic has irreversibly shifted the focus of construction industry participants to pay more attention to the protection and promotion of construction workers' health in the future. We sincerely hope this is the case. However, it is also apparent that changing the industry's culture and deeply entrenched practices is needed to effect sustainable improvements.

No single organisation or entity is likely to be able to change the challenge of long work hours, for example, because these are driven by deep-rooted characteristics of the competitive tendering and procurement processes. Greater collaboration between client organisations, construction firms and unions is likely to be needed to resolve some of the long-standing (and well-documented) characteristics of construction jobs that affect workers' health and wellbeing. It is also important that researchers continue to address ways to improve the health and wellbeing of construction workers. Rigorous intervention studies are particularly necessary as much research to date has focused on diagnosing the problems rather than evaluating ways to resolve them. Multidisciplinary work is also much needed in the context of increasingly complex challenges with the potential to cause harm (e.g., climate change).

We see this book as the starting point for an industry-academic conversation about what is needed to produce measurable improvements in construction workers' health and wellbeing in the coming years.

1

INTRODUCTION

The health imperative

1.1 Introduction

There has been a great deal of focus and many resources allocated to understanding and preventing injury in the construction industry (the "S" in OH&S) but limited attention has been given to workers' health. This book seeks to consolidate what we know about construction workers' health, offers guidance and suggestions to organisations on how they can protect and support the health of construction workers, and identifies some important areas for future research. This book may also be used by construction management and occupational health and safety (OH&S) educators to inform curriculum. Importantly, this book seeks to shift the emphasis away from a sole focus on health as an individual responsibility and takes a broader approach to understanding the characteristics of work and the workplace which can affect workers' health. Critically, we acknowledge that the construction industry's workforce is diverse and heterogeneous, including different groups of workers who perform a wide variety of work tasks across a range of work locations under different organisational and environmental conditions. This diversity has a bearing on health risks and outcomes. However, in this book we suggest that taking a systems approach to construction workers' health can assist in identifying causes of ill-health and guide the controls necessary to protect and promote the health of all workers, irrespective of role, age, or gender.

1.2 The global burden of work-related disease and injury

The United Nations 2030 Agenda of Sustainable Development Goals (SDGs) was adopted by all United Nations Member States in 2015. In order to achieve these goals, specifically SDG3 (Ensure healthy lives and promote well-being for all at all ages) and SDG8 (sustained, inclusive and sustainable economic growth, full

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and productive employment and decent work), there is a need to reduce exposure to occupational health risks and promote health and wellbeing through the provision of well-designed and decent work.

The results of a global monitoring study undertaken on behalf of the World Health Organization and the International Labour Organization found that work-related diseases and injuries were responsible for 1.9 million deaths in 2016 and 89.7 million disability-adjusted life years (DALYs)[1] (WHO/ILO, 2021). Non-communicable diseases accounted for a much larger proportion of deaths (80.7%) than injuries (19.3%). The proportion of disease-related DALYs was also substantially greater (70.5%) than injury-related DALYs (29.5%).

These figures are a stark reminder that occupational health and safety programmes need to focus on the reduction of work-related risks to health as a matter of priority and urgency. The WHO/ILO Global Monitoring Report found that the most frequent causes of work-related deaths attributable to disease were chronic obstructive pulmonary disease (450,381 deaths); stroke (398,306 deaths) and ischaemic heart disease (346,618 deaths). The analysis considered 19 occupational risk factors, including workplace exposure to air pollution, asthmagens, carcinogens, ergonomic risk factors, and noise. Importantly, the 2021 report included exposure to long work hours for the first time. Long work hours were defined as working more than 55 hours each week. Long work hours was the occupational risk factor with the largest number of attributable deaths (744,924) followed by occupational particulate matter, gases and fumes (450,381 deaths). Importantly, deaths from heart disease and stroke associated with exposure to long work hours increased by 41 and 19 per cent respectively between 2000 and 2016, leading the WHO/ILO to identify long work hours as an increasingly important psychosocial occupational risk factor (WHO/ILO, 2021).

The WHO/ILO Global Monitoring Report also suggests preventive actions for each identified risk factor; for example, agreement on healthy maximum limits on working time is suggested to address the risk of exposure to long work hours. Given the prevalence of long work hours in project-based work, the health impacts of long hours of work in the construction industry are specifically addressed in Chapter 4 of this book.

1.3 Workers' health in the construction industry

Construction workers are reported to be relatively unhealthy when compared to the general population. This is sometimes attributed to lifestyle behaviour. For example, the *Australian National Health Survey 2017–2018* found that, compared to workers in other industries, construction workers have higher rates of smoking and alcohol consumption. Further, poor nutrition and levels of overweight and obesity remain high among construction workers. This is a problem for the industry because construction, perhaps more than other industries, relies on fit and healthy workers to perform work tasks that are often physically demanding (Sherratt, 2018). Consequently, construction organisations have sought to introduce health promotion programmes focused on improving a variety of lifestyle behaviours (see, for example, Lingard & Turner, 2015). What these programmes often fail to address is the fact that occupational causes of unhealthy lifestyle behaviours are not addressed by behaviour-focused health promotion programmes. That is people who are exposed to hazardous conditions, physically demanding tasks, high stress levels and long work hours are more likely to smoke and consume too much alcohol and less likely to exercise and eat well (WorkSafe Queensland, 2021).

Construction workers are exposed to a wide variety of occupational health hazards and have a higher incidence of work-related illness including contact dermatitis, all types of skin neoplasma, non-malignant pleural disease, mesothelioma, lung cancer, pneumoconiosis and musculoskeletal disorders compared to workers in other industries (Stocks et al., 2010; Snashall, 2005; Stocks et al., 2011). According to the UK Health and Safety Executive (HSE, 2021), construction has the largest incidence of cancer of any industry sector, accounting for 40 per cent of occupational cancer deaths and cancer registrations. The HSE also estimates that over 5,000 occupational cancer cases and approximately 3,700 deaths each year can be attributed to past exposures in the construction industry. Asbestos (70%), silica (17%), working as a painter and exposure to diesel engine exhaust (6–7% each) were the most prevalent exposures associated with occupational cancer cases in the construction industry (HSE, 2021). Further, lung disease and breathing problems are linked to exposures to dusts, fumes, vapours or gases in the air, while dermatitis is associated with handling many commonly used (but hazardous) construction materials. Construction workers are also exposed to physical occupational hazards, including exposure to noise, hand-arm and whole-body vibration. Construction is a high-risk industry for musculoskeletal disorders (MSDs) (Hartmann & Fleischer, 2005; Latza, et al., 2000). For example, in the USA, 40 per cent of construction workers over the age of 50 are reported to experience chronic back pain (Dong et al., 2012). As a result of exposures to hazardous work conditions, many construction workers experience work disability necessitating early retirement (Brenner & Ahern, 2000; Welch, 2009; Oude Hengel et al., 2012; Arndt et al., 2005).

It has been widely observed that, while considerable attention has been paid to the identification and management of risks to construction workers' immediate safety, far less attention has been paid to the systematic management of workers' health (Jones et al., 2019). The critical need to focus on reducing occupational health risks and some of the challenges associated with doing so are further discussed in Chapter 2 of this book.

Construction workers are also susceptible to mental ill health. The incidence of psychological distress among construction workers is reported to be twice the level of the general male population (Borsting Jacobsen et al., 2013). Petersen and Zwerling (1998) similarly report that construction workers experience a significantly higher incidence of emotional/psychiatric disorders than other manual/non-managerial workers. Suicide rates in the industry are reported to be high in the United Kingdom, Australia and the USA (Meltzer et al., 2008; Centers for Disease Control and Prevention, 2018; Milner et al., 2013). In the context of an already substantial suicide problem, King and Lamontagne (2021) argue that the COVID-19 pandemic has created the "perfect storm" for suicide rates among construction workers to rise steeply. Most at risk are unskilled workers who are often young and who experience lower levels of job security and control than skilled workers (King & Lamontagne, 2021).

1.4 Social determinants of health

It is widely accepted that social – as distinct from biological and genetic – factors have a significant impact on health outcomes. Social determinants of health include "the conditions in which people are born, live, work, and age, and the health systems they can access, which are in turn shaped by a wider set of forces: economics, social, environmental policies, and politics" (Allen et al., 2014, p.392).

The "Dahlgren and Whitehead model" (Figure 1.1) is widely used to depict determinants of population health. Although first developed in 1991, Dahlgren and Whitehead (1991, 2021) observe that the model has proven so popular because it encourages professionals and policymakers (beyond those directly engaged in healthcare or health services) to consider how their activities affect health and what they can do in their sectors and local environments to influence the health of the groups potentially affected by their activities. The model also supports the development of a holistic understanding of health and promotes multisectoral action. While disease-focused models of health can result in fragmented initiatives in which strategies for the prevention of a disease are developed independently of one another, the social determinants model encourages a more comprehensive strategy focused on determinants of health that may contribute to many diseases (Dahlgren & Whitehead, 2021).

Inequality in health (e.g., differences by socioeconomic characteristics, such as education and income) has been reported in many countries, with the worst health experienced by those in the lowest socioeconomic groupings (Denton & Walters, 1999; Braveman & Gottlieb, 2014). However, Dahlgren and Whitehead (2021) also observe that their model does not (nor was it intended to) explain the causes of health inequalities within a particular country or context. In order to understand health inequality, Dahlgren and Whitehead (2021) argue there is a need to examine the ways that the various social determinants create social gradients in health. In particular, the ways that social determinants of health can create inequality have been identified as differences in power and resources, differences in exposure, differences in vulnerability and differences in the consequences of being sick (Diderichson et al., 2001).

Case example 1.1 considers health inequality in the construction workforce which emerged during the COVID-19 pandemic and identifies some of the mechanisms contributing to health inequality for a particular cohort of workers.

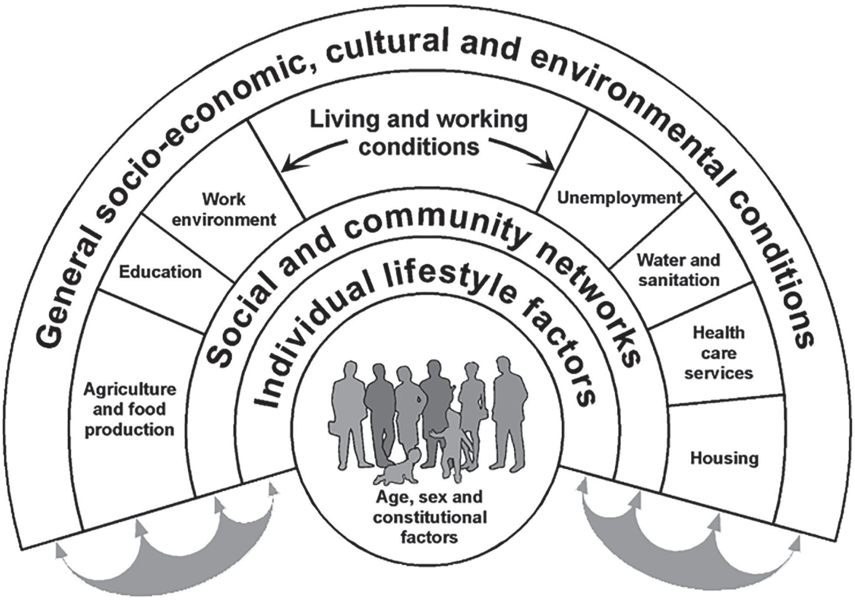

FIGURE 1.1 Model of social determinants of health
Source: Dahlgren & Whitehead, 2021, p.22.

CASE EXAMPLE 1.1 MECHANISMS CONTRIBUTING TO HEALTH INEQUALITY IN THE COVID-19 PANDEMIC

While the COVID-19 pandemic affected the whole workforce in the construction industry, there is emerging evidence to suggest that it had a greater impact on some groups of workers who were more vulnerable than others. The vulnerability was likely to escalate the health, safety and wellbeing risks posed by COVID-19 among these worker groups, leading to health inequalities in the construction workforce (Brown et al., 2020).

In the United Kingdom socioeconomic inequalities between people who were able to work from home (to protect themselves against exposure to COVID-19) and those who could not were observed (Marmot et al., 2020). In particular, 70 per cent of workers in occupations requiring higher qualifications reported they were working from home during a reference week in April 2020 compared with 19 per cent of those in skilled trade occupations and only 5 per cent of process, plant and machine operatives (Marmot et al., 2020). This suggests that people in occupations requiring higher qualifications were afforded greater protection from COVID-19. However, while occupation was an important risk factor for COVID-19 infection and death, the effect of occupational exposure was amplified when people were living in a more deprived area, in poor quality or overcrowded housing, and where they had a pre-existing underlying health condition. People from a black, Asian or minority ethnic background were also more susceptible (Marmot et al., 2020). The vulnerability of migrant construction workers became even more obvious during the COVID-19 pandemic. For example, in Singapore, migrant workers were housed in congested dormitories isolated from the rest of the population and had less access to masks (Koh, 2020; Geddie & Aravindan, 2020), making infection risk among migrant workers significantly higher than the rest of the population.

Recognising that individuals' opportunities and choices in relation to health-related behaviours can be influenced by the contexts in which they work highlights the opportunity for organisations to promote health and/or remove barriers that might prevent people from engaging in healthy behaviours (Braveman et al., 2011). Systematic reviews have identified workplace interventions as having a positive impact in improving health and reducing health inequality (Bambra et al., 2010). However, primary interventions that focus on changing job conditions or work characteristics (rather than changing workers' lifestyle behaviour) are most beneficial. For example, interventions designed to increase workers' participation and control over their conditions of work, changing the organisation of shift patterns and addressing specific occupational hazards were all found to have positive impacts on workers' health (Bambra et al., 2010). Allen et al. (2014) similarly report that poor quality employment and jobs with low levels of reward and control have a damaging effect on mental health. By promoting greater job control and decreased demand, employers can reduce stress, anxiety and depression and increase self-esteem, job satisfaction and productivity (Allen et al., 2014).

As previously noted, many workplace health promotion programmes aim to modify individuals' lifestyle behaviours, such as smoking, alcohol consumption, exercise and diet (Bambra et al., 2010). Examples in construction include programmes that have: encouraged exercise to address shoulder pain (Ludewig & Borstad, 2003) and improve aerobic capacity (Gram et al., 2012); sought to help workers to reduce their weight and risk of cardiovascular disease (Groeneveld et al., 2010); and to encourage smoking cessation and the consumption of fruit and vegetables (Sorensen et al., 2007). However, the extent to which these programmes are genuinely informed by workers' participation and choice has been questioned (Sherratt, 2015).

Research also confirms that fundamental structures of social inequality are more influential in determining a person's health than behavioural factors (Denton & Walters, 1999). In particular, structural sources of inequality may actually underpin unhealthy lifestyle behaviours. Consequently, Dahlgren and

Whitehead (2021) argue that "vertical links" are needed in the determinants of health model depicted in Figure 1.1 to show how social, economic and cultural factors are linked to lifestyle behaviours. In reality, what appear to be lifestyle "choices" may be substantially constrained by structural factors, including work and family responsibilities, occupational status and income adequacy. These structural socioeconomic factors can impact health directly as well as indirectly, through their influence on health-related behaviours (Denton & Walters, 1999).

Zoller (2003) argues that the lifestyle focus of many workplace health promotion programmes de-emphasises social factors that shape the way people behave. The emphasis on living a healthy lifestyle thus shifts the focus away from the underlying (and often very deeply entrenched) causes of workplace-generated disease and frames health as a matter of individual choice. Sherratt (2018) similarly argues that the positioning of worker health as a personal lifestyle choice does not reflect the way that work practices in the construction industry induce high levels of stress that contribute substantially to unhealthy lifestyle behaviours.

To illustrate this point, the role of long work hours and time poverty in shaping construction workers' response to a lifestyle-focused workplace health programme is described in case example 1.2, as follows:

CASE EXAMPLE 1.2 TIME POVERTY AS A STRUCTURAL IMPEDIMENT TO HEALTH BEHAVIOUR CHANGE IN THE CONSTRUCTION INDUSTRY

A health promotion programme targeting the behaviour of construction workers at two worksites in the Queensland construction industry was evaluated by the authors. At these sites, initiatives were introduced including:

- a smoking cessation campaign,
- health-based information sessions and healthy food tasting sessions,
- a change of food options sold in the site canteen,
- a waistline measurement activity,
- yoga/stretching sessions, and
- discounted gym memberships.

Workers worked six days per week, and often had to travel long distances for work. During the summer months, the site operated from 6am, and during winter from 6.30am. Finishing time varied according to overtime worked. Participants indicated they were frequently unable to find the time to prepare and eat healthy food or engage in physical exercise. During the programme the authors used diary-based methods to record workers' health behaviour. The results produced no evidence of significant or sustained behaviour change (Lingard & Turner, 2015).

Site workers' comments revealed that a shortage of time acts as a major structural impediment to leading a healthy lifestyle. One described their day as follows: "[I] *leave home at 4.45am because I kick off in the mornings. By the time you come home, feed the dog, clean the house, wash your clothes, eat, that's it.*" Another worker commented: "*I don't have time to go for a walk. When I lived in town (closer to work) I'd get up at 4.30am and walk for an hour. Now if I did that I'd get up at 2.30am (because of extra travel time). I just wouldn't have any time to sleep.*" Another commented: "*Time is the biggest barrier. If you don't have the time, you don't have the time. If you want to do something extra in your day, you will be doing it before you go to work in the dark. By the time you get home, you are exhausted and just want to sit down, you don't want to do anything.*"

A shortage of time was identified as a factor contributing directly to lifestyle and poor health: "*You get into a cycle. There's not enough time. It's hard to step back and make a change in your lifestyle. You get into a pattern of eat, smoke, drink, sleep. Then you wake up and do it all again. Before you know it you have put on 20 kilos.*"

Adapted from Lingard & Turner, 2015, 2017

However, workplace health promotion programmes are rarely subjected to critical examination. One of the challenges lies in the fact that the boundary between factors that influence health at work and outside work is blurred. In this way, health is arguably far more complex an issue to deal with than workplace safety. Assessing the work-relatedness of illness and disease is not always simple. Similarly, concerns have been raised as to whether it is appropriate for organisations to try to control or manage workers' health beyond the workplace (and, if so, to what extent?).

Some studies have examined the operation of workplace wellness programmes in relation to their underlying rationale and motivation, as well as potentially negative impacts. These more critical perspectives are important to acknowledge and consider in relation to how construction organisations can better address issues of worker health and wellbeing.

For example, Sherratt (2015) argues that the implementation of workplace health promotion interventions may be motivated more by corporate interests than by a philanthropic interest in workers' health. This view is shared by Holmqvist (2009) who suggests that a desire to manage uncertainty in the organisation's operational environments underpins many corporate health promotion activities. Conrad and Walsh (1992) similarly view workplace health/wellness programmes as a means through which business tries to shape the values, attitudes and behaviour of workers for the purpose of improving productivity and performance.

Value statements used to promote workplace health initiatives often reflect a managerial ethic of production efficiency and performance (Johannson &

Edwards, 2021). Sherratt (2015) points out how a significant UK industry policy document (The Responsibility Deal Construction Pledge) emphasises the number of days lost due to sickness in its appeal to construction employers to "step up" and do something about workers' health. She argues that this constructs worker health as "simply the ability to be present and participate in work" (Sherratt, 2015, p.448).

Workplace health/wellness programmes have also been criticised for defining health in specific and often quite narrow ways. The social construction of what a "healthy" body looks like is largely based on notions of physical fitness and performance linked to behaviours characterised by abstinence, self-control, hard work and competitiveness (Zoller, 2003). In painting a narrow and homogeneous interpretation of what it means (and looks like) to be healthy, workplace health promotion programmes can also stigmatise workers who do not conform to organisationally created norms and values (Johannson & Edwards, 2021). This can marginalise certain groups in the workforce, e.g., those whose bodies for reasons of gender, class, caring responsibilities, disability, maternity, etc., do not conform to the idealised notion of what a healthy (and therefore competent) worker looks like (Holmqvist, 2009).

1.5 Motivation for managing workers' health

The World Health Organization (2019) identifies an inextricable link between employment and health and observes the important contribution to be made by workplaces in the pursuit of global Sustainable Development Goals (SDGs) and reduction of health inequalities. In particular, Goal 3 "Ensure healthy lives and promote well-being for all at all ages" and Goal 8 "By 2030 have sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" focus attention on workers' health and the provision of good quality jobs. However, other SDGs also apply to the protection of workers' health, for example, SDG 10: "Reduced inequalities" and SDG 16: "Peace, justice and strong institutions." Moreover, in June 2022, delegates attending the International Labour Conference (ILC) adopted a resolution to add the principle of a safe and healthy working environment to the International Labour Organization's (ILO) Fundamental Principles and Rights at Work. Thus, occupational health and safety was added to the previously agreed four principles:

- freedom of association and the effective recognition of the right to collective bargaining;
- the elimination of all forms of forced or compulsory labour;
- the effective abolition of child labour; and
- the elimination of discrimination in respect of employment and occupation (ILO, 2022).

Smallwood and Lingard (2009) argue that the motivation for organisations to protect and promote workers' health (and also safety) is multi-faceted and can include legal considerations, moral/religious beliefs, ethical considerations; humanitarian concerns and a respect for people; a desire for sustainability; compliance with national and international standards; a desire to reduce the costs of workers' compensation, absenteeism and turnover; the desire to reduce organisational risk; adherence with total quality management principles; support of local industry, corporate image and reputation considerations and the pursuit of better practice. The World Health Organization (2010a) similarly suggests three primary reasons for organisations' willingness to exert effort and expend resources to protect and promote workers' health.

1.5.1 Moral/ethical considerations

The "golden rule" establishing a moral level of care for other people is common to most of the world's major religions, philosophies and value systems (Eckhardt, 2001). Thus, it is morally wrong to treat people in certain ways (Rowan, 2000) and the avoidance of inflicting harm on others is a basic ethical/moral principle (WHO, 2010a). Organisational activities (for example, exposure to workplace hazards as a result of the way that work is designed and performed) can have consequences for workers' physical and mental health. The moral nature of organisational decision-making is amplified because workers are often dependent upon jobs for their livelihood, may have little knowledge of the health hazards to which they are exposed, and have little control over conditions of work. Consequently, there have been calls for organisational decision-making to be guided by ethical codes and guidelines (Greenwood, 2002). However, the World Health Organization (2010a) argues that moral codes adopted by many societies and cultures are often limited in their application to "personal" decisions and actions and are seldom considered in relation to the operation of business. As previously noted, the right to a healthy and safe work environment, identified as a fundamental human right at the XVIII World Congress on Safety and Health at Work held in Seoul, Korea (WHO, 2010a), has now also been included in the International Labour Organization's (ILO) Fundamental Principles and Rights at Work (ILO, 2022). Thus, the right to a healthy and safe workplace is universally held by workers, and employers therefore have a concomitant duty to provide a healthy and safe work environment.

1.5.2 The business case

The economic impacts of workers' poor health and potential benefits to be gained from protecting and promoting workers' health are often cited as the incentive for organisations to invest in workplace health programmes. For private businesses this motivation aligns with the view that the principal responsibility of business is to make a profit. Success in non-profit and public sector organisations involves the achievement of an established purpose. The ability to meet organisational goals is dependent upon workers in private as well as non-profit and public organisations. Unhealthy (and unsafe) work environments have been linked to increased operating costs, decreased productivity, decreased quality of products and services leading to customer dissatisfaction, fines and even potentially imprisonment (WHO, 2010a). These factors are preceded by higher levels of absenteeism, presenteeism, rising health insurance costs and workers' compensation claims, industrial disputes and employee turnover (WHO, 2010a). The "business case" is widely accepted as a driver for organisational initiatives to protect and promote workers' health. Indeed, commentators identify the need to evaluate the impacts of workplace health programmes using a variety of health and economic measures to properly understand the business outcomes of these programmes (Adams, 2019). The return on investment of workplace wellness programmes has received considerable attention in the business/management literature, with analysts claiming an impressive ratio of total benefits achieved for every monetary unit spent on a programme (Berry et al., 2010; Baicker et al., 2010). However, it is also recognised that some health-related phenomena (for example, presenteeism) are difficult to monetise and may not be reliably captured in organisationally generated datasets (McLellan, 2017). Despite multiple accounts of favourable cost-benefit ratios, a systematic review of workplace wellness programmes conducted in Europe (and evaluated in rigorous randomised controlled trials) showed the economic impacts to be mostly negative, i.e., the costs of implementation outweighed the monetised benefits (Martinez-Lemos, 2015). A similar review of studies undertaken in the USA also failed to find evidence of a positive return on investment in the short term (Baid et al., 2021). The expectation of a favourable ratio of costs to financial benefits may not, therefore, act as a motivator for the implementation of workplace wellness initiatives where clear and measurable cost benefits are not evident. In such circumstances questions arise as to whether or not employers are willing to pay for workers' improved health, the extent to which they are willing to do so and what types of mechanisms may be needed to encourage organisations to more fully address issues of workers' health (Martinez-Lemos, 2015).

1.5.3 Legal requirements

Most countries have enacted some form of legislation requiring employers to take measures to protect their workers from workplace hazards that could cause illness or injury. In some countries, these laws are sophisticated and impose duties on other parties whose activities could be harmful to workers who may not be their direct employees (for example, designers, manufacturers, importers and suppliers of plant or substances, as well as owners and managers of facilities/workplaces and designers of structures). In many instances, laws specifically focus on the elimination or reduction of risks. For example, in Australia, the Model Work Health and Safety Act (which was established as the basis for creating national consistency between Australia's states and territories, each of which has its own occupational health and safety legislation) states that the duty to "ensure health and safety requires the person:

a) to eliminate risks to health and safety, so far as is reasonably practicable; and
b) if it is not reasonably practicable to eliminate risks to health and safety, to minimise those risks so far as is reasonably practicable" (Safe Work Australia, 2019, p.15).

The Model Act is also supplemented with a raft of more detailed and prescriptive requirements in the Model Work Health and Safety Regulations. Many of these regulations refer specifically to occupational health-related hazards/risks, including managing risks in relation to noise, hazardous manual tasks, hazardous chemicals, lead and asbestos. The regulations include detailed health monitoring requirements for workers exposed to lead, asbestos and certain specified hazardous chemicals, as well as audiometric testing for people exposed to high levels of noise. Detailed requirements are specified for risk controls that must be implemented in certain situations, specific personal protective equipment requirements and facilities that need to be provided for changing, washing, laundering or disposing of contaminated personal protective equipment following exposure to hazardous environments and substances (Safe Work Australia, 2021).

Given the existence of occupational health and safety legislation in most countries, employers may be motivated to take steps to reduce risks of work-related illness and protect workers' health in order to avoid fines or imprisonment in the case of serious breaches. However, the WHO (2010a) observes that occupational health and safety legislation varies significantly from country to country so coverage will be inconsistent. The extent to which employers are focused on preventing harm to workers' health may also depend upon the efficacy of enforcement activity in a particular jurisdiction. Further, Sherratt (2018) observed that UK construction contractors' emphasis on public health issues, such as diet and exercise, detracted from their willingness to invest in programmes focused on the reduction of widely recognised occupational health risks. This is reflected in a quotation attributed to a senior occupational health and safety manager in the industry that "it's no good giving people fruit and porridge as they come through the turnstile if we're then giving them exposure to dust and carcinogens…" (CIOB, 2016, cited in Jones et al., 2019, p.546).

Given the serious and potentially irreversible effects of work exposures on health, the World Health Organization (2010a) advocates for the precautionary principle to be applied. That is: employers and workers should not delay implementing interventions to address workplace conditions and promote health simply because intervention effectiveness has not yet been rigorously evaluated and its efficacy demonstrated (p.43).

1.6 What constitutes a healthy workplace?

The World Health Organization has defined health broadly as "a state of complete physical, mental and social well-being, and not merely the absence of disease" (WHO, 2010b, p.15). In most countries, employers have responsibilities under occupational health and safety legislation for the prevention of work-related illness and injury. However, workplaces are increasingly viewed as an appropriate setting within which health promotion can occur.

The WHO defines a healthy workplace as "one in which workers and managers collaborate to use a continual improvement process to protect and promote the health, safety and well-being of all workers and the sustainability of the workplace by considering the following, based on identified needs:

- health and safety concerns in the physical work environment;
- health, safety and well-being concerns in the psychosocial work environment, including organization of work and workplace culture;
- personal health resources in the workplace; and
- ways of participating in the community to improve the health of workers, their families and other members of the community" (WHO, 2010b, p.6).

This definition reflects the importance of collaboration between managers and workers in relation to preventing illness and promoting health and of being inclusive in providing support to all workers.

To support the practical development of healthy workplaces, the WHO (2010a) developed a healthy workplace model, depicted in Figure 1.2. This model shows four avenues through which employers (in collaboration with workers) can influence the health of their workers, including the physical work environment, the psychosocial work environment, workers' personal health resources and the involvement of an enterprise within the broader community in which it operates.

The definitions of each of these avenues is included in Table 1.1 below:

The WHO healthy workplace model also incorporates an organisational implementation process (based on existing "continual improvement" models) through which workplace health programmes can be initiated, collaboratively designed, planned, resourced, implemented, evaluated and improved (Figure 1.2).

At the heart of the WHO model lie some fundamental principles that are likely to be critical to the success of a workplace health initiative. These are:

- the engagement of leaders within the organisation to ensure workplace health initiatives are integrated into an organisation's business strategy, goals and values, and senior management commitment that is communicated clearly and consistently to all within the organisation; and
- the meaningful and active involvement of workers and/or their representatives across the entire implementation process. Workers' opinions should be sought at each step in the implementation process and their ideas listened to and used to inform decision-making.

Another model of worker health, the Total Worker Health model, was developed by the National Institute for Occupational Safety and Health (NIOSH) in the United States and aims to integrate occupational safety and health protection

TABLE 1.1 Avenues of workplace influence on worker health

Avenue	*Definition*
Physical work environment	"The part of the workplace facility that can be detected by human or electronic senses, including the structure, air, machines, furniture, products, chemicals, materials and processes that are present or that occur in the workplace, and which can affect the physical or mental safety, health and well-being of workers. If the worker performs his or her tasks outdoors or in a vehicle, then that location is the physical work environment." (WHO, 2010a, pp.77–78)
Psychosocial work environment	"Includes the organization of work and the organizational culture; the attitudes, values, beliefs and practices that are demonstrated on a daily basis in the enterprise /organization, and which affect the mental and physical well-being of employees. These are sometimes generally referred to as workplace stressors, which may cause emotional or mental stress to workers." (WHO, 2010a, p.79)
Personal health resources	"The supportive environment, health services, information, resources, opportunities and flexibility an enterprise provides to workers to support or motivate their efforts to improve or maintain healthy personal lifestyle practices, as well as to monitor and support their ongoing physical and mental health." (WHO, 2010a, p.80)
Enterprise community involvement	"The activities, expertise, and other resources an enterprise engages in or provides to the social and physical community or communities in which it operates; and which affect the physical and mental health, safety and well-being of workers and their families. It includes activities, expertise and resources provided to the immediate local environment, but also the broader global environment." (WHO, 2010a, p.81)

Source: After WHO, 2010a.

with workplace efforts to promote worker health and wellbeing (Schill & Chosewood, 2013). NIOSH describes a Total Worker Health approach as the "policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury- and illness-prevention efforts to advance worker well-being" (Lee et al., 2016, p.1). Total Worker Health has five defining elements, many of which are consistent with models of workers' health that take an integrated approach:

1. Demonstrate leadership commitment to worker safety and health at all levels of the organisation.
2. Design work to eliminate or reduce safety and health hazards and promote worker wellbeing.
3. Promote and support worker engagement throughout program design and implementation.

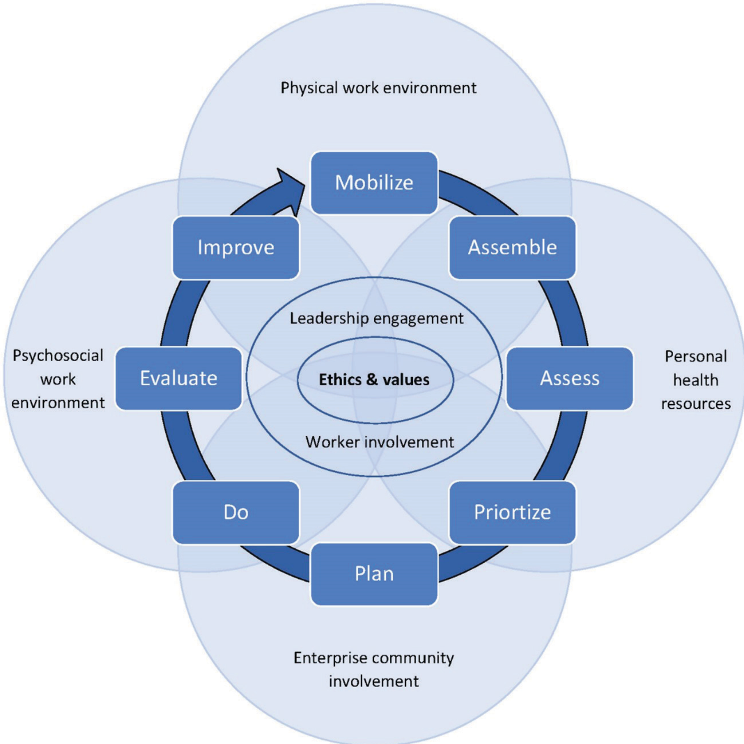

FIGURE 1.2 Healthy workplace model
Source: (WHO, 2010a, p.8).

4. Ensure confidentiality and privacy of workers.
5. Integrate relevant systems to advance worker wellbeing (Lee et al., 2016, p.3).

The five defining elements are positioned as guiding principles for organisations seeking to develop workplace policies, programmes, and practices that contribute to worker safety, health and wellbeing (Tamers et al., 2019).

To strengthen the link between traditional OH&S approaches and Total Worker Health, the Office for Total Worker Health published the "Hierarchy of Controls Applied to NIOSH Total Worker Health," adapted from the hierarchy of controls framework traditionally used in OH&S (Lee et al., 2016). The controls and strategies are arranged in descending order of likely effectiveness and protectiveness (NIOSH, 2017):

- **Eliminate** workplace conditions that cause or contribute to worker illness and injury, or otherwise negatively impact wellbeing. For example, remove harmful supervisory practices throughout the management chain.

- **Substitute** unsafe, unhealthy working conditions or practices with safer, health-enhancing policies, programmes, and management practices that improve the culture of safety and health in the workplace.
- **Redesign** the work environment for improved safety, health, and wellbeing. Examples include removing barriers to improving wellbeing, enhancing access to employer-sponsored benefits, and providing more flexible work schedules.
- **Educate** on safety and health to enhance individual knowledge for all workers.
- **Encourage** personal behaviour change to improve safety, health, and wellbeing. Assist workers with individual risks and challenges, while providing support in making healthier choices.

As implicit in the hierarchy of control, the emphasis is on addressing system-level or environmental determinants of health before relying on individual-level approaches (Tamers et al., 2019). The central role of working conditions in shaping safety, health and wellbeing is shown in Figure 1.3 (Sorensen et al., 2021). Recently, the Total Worker Health approach was expanded to include the broader forces that affect the organisation and workers' health, and this is reflected in Figure 1.3. Employment and labour patterns are particularly relevant to construction workers, as employment is often precarious, providing little job security, and long and irregular work hours are the norm. It is common practice that trade and semiskilled workers are subcontracted by the primary contractor to undertake a specific and time-limited task, and it is possible that workers can work across multiple sites for different contractors and therefore experience multiple health and safety practices. Such employment and labour patterns are

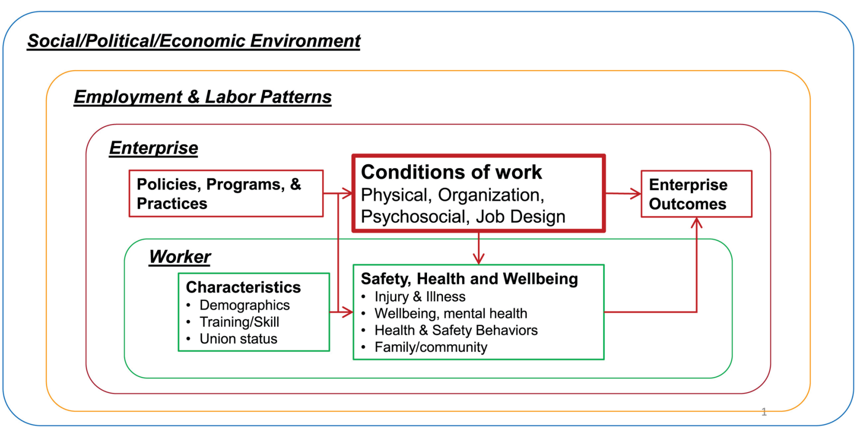

FIGURE 1.3 Systems level conceptual model of work, safety, health and wellbeing

Source: (Sorensen et al., 2021, p.3).

known to be associated with poor health outcomes (Sorensen et al., 2021). Social, political and economic environments include structural forces that influence employment and labour patterns, shape working conditions at the organisation (enterprise) level, and affect worker safety and health. For example, governments vary widely in their approach to protecting workers' safety and health and this is reflected in policy and regulatory requirements.

1.7 The way work is done in construction

The construction industry presents some particular challenges in relation to the protection and promotion of workers' health. The delivery of a construction project is characterised by complex inter-organisational relationships and long (and often complicated) supply chains (Dubois & Gadde, 2000; Hartemann & Caerteling, 2010). The allocation of risk in a construction project is stipulated in contracts, which have become highly diversified to respond to the variety of procurement options and situations. Unfortunately, rather than foster a genuinely collaborative approach, competitive tendering and commercial arrangements can create structural (cost and time) impediments to the protection and promotion of workers' health. Some of these structural impediments are discussed in Chapter 4 in relation to long work hours and health.

Further, most physical construction work is performed by workers who are engaged by subcontractors, are self-employed or are engaged via labour hire agencies. Research suggests that different forms of precarious and/or indirect employment create particular challenges for workers' health. For example, subcontracted workers are reported to be significantly more affected by work-related disease than direct employees (Min et al., 2013). Similarly, the health and safety of agency workers are negatively affected due to pressures, disorganisation and regulatory failure reflected in Table 1.2.

TABLE 1.2 Risk factors associated with precarious employment

Economic and Reward Pressures	*Disorganisation*	*Regulatory Failure*
Insecure jobs (fear of losing job)	Short tenure, inexperience	Poor knowledge of legal rights, obligations
Contingent, irregular payment	Poor induction, training and supervision	Limited access to OH&S, workers' compensation rights
Long or irregular work hours	Ineffective procedures and communication	Fractured or disputed legal obligations
Multiple jobholding	Ineffective OH&S management systems/ inability to organise	Non-compliance and regulatory oversight (stretched resources)

Source: Underhill & Quinlan, 2011.

The transient nature of employment in the construction industry has been identified as a challenge for implementing health assessments, arranging follow-ups as workers move from project to project and managing systematic health surveillance programmes (Jones et al., 2019). Sherratt (2018) points out that, even when construction organisations commit to ambitious targets for health education, training, screening, etc., in reality, many health initiatives are limited to directly employed workers or those who remain at a worksite long enough to partake. Consequently, health protection and promotion in the construction industry are likely to require initiatives that extend beyond the boundaries of a single organisation and operate at an industry or sector level.

1.8 Gender, work and health

The World Health Organization (2011) also recommends a gender-based approach or analysis (GBA) be applied to the design, implementation, monitoring and evaluation of workplace health-related policies, programmes and practices (p.21). The WHO argues that women and men experience work health and safety in different ways and are affected differently by risk exposures and health problems. Women are very under-represented in the construction industry in many countries and, consequently, relatively little is known about the risk exposures and health experiences of women in this sector. Many studies of workplace health "control" for gender in statistical analysis, thereby masking potentially important differences between men and women workers' experiences (Messing & Östlin, 2006). Owing to the fact that women are not well-represented in the construction workforce, it is difficult to collect sufficient population-level data to properly understand their health experiences and more research in this area is needed. Notwithstanding this, even when doing the same job, women and men can experience and be affected by working conditions differently. In particular, equipment, tools and clothing designed for men may not be suitable for women, given differences in average body size and dimensions (WHO, 2011). Women and men also differ in terms of their domestic and unpaid work responsibilities, including providing care for children and the elderly and undertaking household work. This can place women under particular strain as unpaid work combined with participation in paid work can contribute to stress, fatigue and depression (WHO, 2011). Hochschild famously described how women effectively work a "second shift" when they return home from work each day (Hochschild & Machung, 1989).

Moreover, women in traditionally male-dominated industries, such as construction, are more frequently exposed to gender-based violence (including sexual harassment) at work. For example, the Australian Human Rights Commission (2020) reports that male-dominated workplace cultures have a higher prevalence of sexual harassment due to the unequal gender ratio (a higher proportion of men than women in the workplace). Construction was singled out as a high-risk industry for gender-based violence against women. Gender-based violence is a serious occupational health issue (WorkSafe Victoria, 2020) and research highlights the urgency of ensuring that construction workplaces are both psychologically and physically safe for women (Turner et al., 2021).

A gender-based approach to understanding and responding to the needs of women workers can help to ensure workplace health policies, programmes and practices support equity in health and gender within a work environment and can ensure that, in male-dominated industries like construction, the specific health risks and experiences of women workers are effectively addressed (WHO, 2011). We explore the health issues related to women in construction in Chapter 5.

1.9 The rest of this book

This book draws on research work that has been undertaken over a ten-year period. During this period, construction industry stakeholders, including client organisations, employers and trade unions, have grown increasingly aware of the impact of the construction industry's employment practices and working conditions on workers' health. The emphasis has shifted from an exclusive focus on the management of occupational health and safety risks to a recognition that organisations can and should also implement programmes to promote the health and wellbeing of their workforce. It is now widely understood that employment in the construction industry affects the health and wellbeing of workers whether they occupy manual/non-managerial or managerial/professional roles. Yet the work health challenges of the construction industry cannot be resolved by behavioural solutions alone. Recognising the social determinants of health and addressing the systemic environmental factors that affect the health of construction workers is critical. This will require careful consideration of entrenched industry structures and modification to long-standing working conditions and practices.

The remaining chapters of the book recognise that social determinants of health are at play in the construction industry and explore the manner in which these operate. Where possible, health promotion interventions are described and evidence as to their effectiveness presented.

The chapters are organised in the following structure:

Chapter 2 considers the "H" in OH&S. It commences with a discussion of who should be responsible for managing workers' health in an industry in which work is decentralised, the workforce is peripatetic and workers are exposed to a wide range of work-related health hazards. The chapter then goes on to explore why managing occupational health is more complicated than managing safety but emphasises that implementing the most effective control measures for occupational health hazards is critical. Following this is an overview of some of the common hazards and related health issues that are found in construction, including occupational cancer, respirable silica, occupational hearing loss, and musculoskeletal disorders.

Chapter 3 examines the work-related factors which can affect construction workers' psychological health. The key theories linking work with psychological health are outlined, followed by a description of the relationship between conditions of work and work-related stress among construction industry workers. The chapter then provides an overview of psychological hazards and the types of workplace mental health programmes implemented to address these hazards. These programmes are considered in relation to the extent to which they address systemic and environmental issues or whether they primarily focus on individuals' behaviour and ability to cope with work-related stressors. An overview of ISO 45003 (Occupational health and safety management – Psychological health and safety at work) is provided which considers the management of psychosocial risks and promotion of wellbeing at work as part of an organisation's occupational health and safety management system.

Chapter 4 examines different approaches to working time and its effects on the health and wellbeing of workers. The chapter considers how time is understood in project-based construction work, and the connection between long work hours and health and wellbeing is outlined. Challenges experienced in balancing time spent at work and non-work related activities are explored, and consideration is given to the role played by gender in shaping work–life interactions and experiences. The chapter outlines the relationships between long work hours, overtime, and the way that work is scheduled, including modifications and reductions in the "working week," and outlines what alternatives are possible for project-based construction workers. The right to disconnect from the pressures and activity of work after leaving the worksite is discussed, as are the new-found flexible working arrangements that have been adopted by necessity during the COVID-19 pandemic. The chapter ends with a consideration of the systemic factors contributing to long and rigid hours in construction and identifies the need for a whole-of-industry approach to addressing these factors.

Chapter 5 focuses on the occupational health of women working in construction. The health inequality of women from a societal perspective is outlined, and consideration is given to how this is reflected in occupational health research. We consider gender as a social determinant of health, and how the health of women is impacted by their status as a numerical minority group in the male-dominated construction industry. The chapter outlines the characteristics of work and the workplace and how they can be detrimental for the physical and mental health of women. We explore the discrimination-health relationship and in what manner this manifests for women in construction. The psychosocial risk factor of bullying is considered, and the ways in which gendered work hazards are perpetuated in the construction industry are outlined and their impacts on health are identified. We finish the chapter by determining how construction workplaces designed for men can have a detrimental impact on the health of women, and argue that sex (biological differences) and gender (social roles) must be considered in the design of work which seeks to reduce or remove harmful work hazards.

Chapter 6 explores the role of employee resilience and its relationship to wellbeing. Resilience is defined in multiple ways and we review the various definitions of resilience and consider how this translates into definitions of team resilience and employee resilience. Given the definitional and empirical limitations of team resilience, the chapter goes on to focus on the antecedents and outcomes of employee resilience. Protective factors emerging from the individual and organisation which support employee resilience are outlined. The interactionist approach to resilience is considered, and this is important as it positions the organisation as an important contributor to employee resilience. Criteria guiding resilience-building programmes in the workplace are outlined. The chapter also considers how organisations can support the resilience of their employees and outlines various interventions which have been trialled and met with mixed results.

Chapter 7 reviews construction workers' health and wellbeing in the Sub-Saharan African region. The chapter describes how economic and social issues affect the characteristics and working environment of the construction industry in the Sub-Saharan African region. Diseases and infections prevalent in the community are outlined, together with a description of how these affect the construction workforce. The chapter also describes the regulations and practices relating to industry health testing in South Africa. Family and lifestyle issues and their impact on health and wellbeing are described. The chapter finishes with a consideration of organisational supports which are available to construction workers in the Sub-Saharan African region.

Chapter 8 provides an overview of the occupational hazards young construction workers are exposed to when working onsite. Consideration is given to why the health of young workers is more adversely affected than that of older workers. Research on the work experience of apprentices is described, and the mental health implications are considered. Why young workers hesitate to speak up about unsafe work practices is explored, as are psychologically damaging incidences of humour, banter and teasing. The importance of social support from supervisors for young construction workers is examined. The chapter finishes by outlining programmes which seek to protect and promote the health and wellbeing of young workers. Finally, the importance of focusing on the work and social environment of young workers rather than focusing solely on the individual is examined.

Chapter 9 addresses the health and wellbeing of manual/non-managerial construction workers as they age. The chapter starts by considering global trends of the ageing workforce and more specifically the construction workforce. The ageing process and its impact on construction workers' workability is then examined. The interplay between occupational risk factors and individuals' health-related behaviours and how they shape work disability outcomes are explored. The chapter then considers the impacts of exposure to occupational health risks, workplace fatalities and severe injuries, and psychosocial risk factors and how these are associated with older workers. A lifespan perspective is used to examine the sequence of interactions between individual (biological and psychological) and contextual (social and environmental) determinants of development to understand older workers' work and health-related experiences. The chapter finishes with an overview of effective age management and outlines interventions designed to protect and promote the health and wellbeing of older workers.

Chapter 10 presents and discusses a new theoretically based model developed for supporting a mentally healthy workforce. This model is based on the sense of place concept and is aligned with a positive psychology approach which focuses on creating a work environment in which workers can flourish. The six elements of the sense of place model are examined to explore their relationship with workers' mental wellbeing. The six elements of the model comprise social support, community, life balance, engagement, respect, and resilience. The chapter finishes by presenting results of a pilot study which tested the reliability, validity and usefulness of the sense of place model in a construction project workplace.

Chapter 11 draws out the conclusions of the book. The chapter starts with a description of the unexpected turn of a global pandemic and consideration of how this affected workers' health and wellbeing in construction. Lessons learned from working from home during the COVID-19 pandemic are examined, followed by a discussion of future issues in work and health. Following this, the implications of climate change for construction workers' health and new models of work and health are explored. Finally, the use of technology in construction and its impact on workers' health are considered.

1.10 Discussion and review questions

1. Why is the social determinants of health model an important perspective to use when considering workers' health?
2. What are the main motivations for managing workers' health?
3. Whose responsibility is it to ensure that workers have and are able to sustain a positive state of physical and mental health?

Note

1 One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent cases of the disease or health condition in a population. www.who.int/data/gho/indicator-metadata-registry/imr-details/158, accessed 4 October 2021.

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2

ATTENDING TO THE "H" IN OH&S

> I still think there is a bit of a view that health is secondary to safety, which is obviously what we're trying to eliminate. I think if we see good performance in the health bit, it's normally quite a good indicator that an area is taking everything very seriously.
>
> *Health and Safety Director*

2.1 Introduction

In this chapter we provide a brief overview of the challenges inherent in managing occupational health in the construction industry and some of the major occupational health risk factors to which construction workers are exposed. We highlight the importance of applying the hierarchy of control to ensure that occupational health risks are controlled as effectively as possible, by targeting health hazards at source and preventing (or at least substantially reducing) exposures. Examples are provided of initiatives that have effectively reduced exposures to occupational health risks in the sector. Some of these initiatives involve changes to national and international regulatory frameworks governing the manufacture, importation and supply of products and materials, others involve the adoption and use of new tools and technologies within particular organisations or projects. While the chapter cannot cover all occupational health issues relevant to construction work, the discussion and examples we offer are intended to provide evidence of the need to do more to manage occupational health (as well as safety) in the construction sector. The chapter also provides insights into actions that can be taken at government, industry, organisation and project levels to reduce the construction industry's unacceptably high incidence of work-related disease.

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2.2 Who should be responsible for managing workers' health?

While everybody can and should take responsibility for looking after their own health in relation to the things over which they have control, workers are often exposed to conditions that can adversely affect their health, and over which they have little or no control. Occupational health and safety legislation exists to ensure that organisations and individuals who manage worksites, and other parties such as organisations and individuals who design, manufacture and supply plant, equipment and substances take reasonable steps to control risks of harm to workers' health, as well as to their safety.

The point of departure for this chapter is the position that it is unhelpful that occupational health has been subsumed into the catch-all, singular concept of "OH&S." We argue that occupational health is distinct from safety, requiring specific and focused attention and effort in both its regulation and management. However, the identification and control of hazards that present the potential for acute injury (with immediate effects) have tended to take precedence over the management of health risks, the effects of which are often delayed, less well understood, and difficult to envisage. This situation has led to calls for occupational health to be given a higher priority, and recognised as being of equal importance to occupational safety in the construction industry (Jones et al., 2019).

While adverse safety events tend to have immediate effects and occur almost exclusively within the physical workplace, occupational illnesses often develop over a long time period and can also be influenced by individual characteristics and behaviours and environmental factors outside the workplace. Sherratt (2016) argues these differences have reduced the degree of organisational attention that is paid to the elimination or reduction of significant occupational health risks, while placing an unrealistically high degree of emphasis on individual workers' responsibility for managing their own health. This is evident in the emphasis on wellbeing programmes that focus on improving workers' "lifestyle" behaviours, for example providing fruit in workplaces to encourage healthy eating, providing fitness programmes, smoking cessation programmes, etc. While well-intentioned, these programmes do not reduce the risk associated with exposure to many known and serious occupational health risks present in many workplaces. The systematic identification, assessment and control of occupational health risk must be primarily an organisational/managerial responsibility, rather than the responsibility of individual workers.

Construction workers are a high-risk group for poor health that is caused by or made worse by their employment. In the United Kingdom in 2020, 81,000 construction workers were reported to be suffering from work-related ill health (including new or long-standing illnesses) (HSE, 2020a). Musculoskeletal disorders accounted for 57 per cent of these illnesses, followed by stress, depression and anxiety (26 per cent). Reflecting the diversity of exposure to health risks, 17 per cent of reported occupational illnesses in UK-based construction workers were classified as "other illnesses" and included occupational asthma, chronic obstructive pulmonary disease (COPD), contact dermatitis, occupational cancer, occupational deafness and hand-arm vibration (HSE, 2020a). In the USA, the risk of chronic occupational illness over a 45-year working life in construction is 2–6 times greater for construction workers than non-construction workers (Ringen et al., 2014). Ringen et al. (2014) estimate that, in their working lives, 16 per cent of construction workers developed COPD, 11 per cent experienced chest x-ray abnormality, and 74 per cent developed hearing loss.

Understanding the prevalence of occupational illness in the construction industry can be challenging due to the diverse nature of the industry's workforce and the vast array of work-related health hazards to which construction workers are exposed. In European countries, large-scale national health surveillance schemes have been implemented which allow a detailed examination of trends in the annual incidence of occupational disease (defined as "clinically established diseases mainly caused by work" (van der Molen et al., 2016, p.350)). For example, in the Dutch construction industry, van der Molen et al. (2016) report that approximately 13 per cent of construction workers have an occupational disease that has been reported and diagnosed by an occupational physician. Noise-induced hearing loss accounted for two-thirds of these diagnoses, while musculoskeletal disorders were the second most frequently occurring occupational disease. Over a five-year period between 2010 and 2014, the incidence of noise-induced hearing loss increased significantly by 7 per cent and contact dermatitis increased by 19 per cent (van der Molen et al., 2016).

Snashall (2005) argues that, because of the wide variety of activities and tasks involved in construction work, almost every known occupational illness has been reported in the construction workforce. Also, the health risk exposure of construction workers varies considerably depending on their trade. Some health issues are more prevalent in particular trades due to the exposures associated with their work. For example, plasterers, bricklayers and masons are at high risk of contact dermatitis (HSE, 2020a), while tunnellers are exposed to a variety of airborne substances that reduce lung function (Ulvestad et al., 2015). Historically, painters have been at risk of neuropsychiatric disorders arising from exposure to organic solvents (Kaukiainen et al., 2004). However, the increasing use of water-based rather than solvent-based paint that has occurred since the 1970s has reduced the occurrence of chronic toxic encephalopathy or so-called "painters' syndrome" (Decopaint, 2000; Järvholm & Burdorf, 2017).

The substantial variation in hazard exposures and occupational health effects experienced by construction workers requires a nuanced understanding of the risk profile of the workforce in an organisation or project, recognising this may vary between project stages as particular construction activities commence and finish. The ageing construction workforce in many countries is also likely to increase the risk of occupational disease as workers experience higher cumulative exposures over their working lives.

Aside from the human impacts and losses borne by workers and their families who experience a debilitating illness or death arising from a work-related disease, the economic costs of occupational disease are substantial. For example, UK data indicates that occupational illness in the construction industry resulted in more than 1.5 million lost working days each year between 2017/18 and 2019/20. This is compared with 500,000 workdays lost as a result of workplace injury (HSE, 2020a). The UK's Health and Safety Executive also estimates that, in 2018/19, new cases of work-related ill health cost society around £10.6 billion, compared with £5.59 billion for workplace injury (HSE, 2020a).

2.3 Managing occupational health is more complicated than managing safety

Many of the occupational risk factors and resulting diseases experienced by construction workers have been well understood for some time and effective risk controls have been identified. This raises the important question as to why construction workers are still exposed to hazardous work conditions that affect their health to the extent that they do. A variety of reasons has been provided as to why, historically at least, occupational health risks have not been as well managed as occupational safety risks. Some of the challenges are described briefly below.

The long latency period of many diseases (for example, cancers arising as a result of asbestos exposure or neurological damage associated with hand-arm vibration), in which illness may not be experienced until many years after exposure, is sometimes identified as a barrier to effective prevention. An extended time lag between exposure and illness can make attribution of responsibility for harmful exposure to individual employers difficult in an industry like construction in which workers move frequently between projects and may change employers multiple times in their working lives. For example, Dement et al. (2005) suggest that the peripatetic nature of the construction industry's workforce combined with the cost of investment in prevention has contributed to a failure of employers to implement effective and known controls for the risk of noise-induced hearing loss in the US construction industry. Importantly, even if it is difficult to identify employer responsibility for historical exposure leading to illness, this should not preclude the implementation of appropriate measures to eliminate and reduce potentially harmful exposures in the present. As knowledge about the links between workplace exposure and occupational illnesses grows, it is incumbent upon employers and others with responsibility for workplace health and safety to ensure that health risks are identified, understood and effectively controlled to reduce the burden of illness in the future. This may require more significant regulatory intervention to ensure that organisations invest appropriately in the prevention of occupational ill health.

Further, the effects of occupational exposures on ill health can be obscured because of the cumulative and combined effect of exposures at work and outside work. For example, construction workers are a high-risk group for COPD (progressive and irreversible limitation in airflow in the lungs, including chronic bronchitis and emphysema) (Murgia & Gambelunghe, 2021). The primary cause of COPD is smoking, but COPD is also caused by exposures to welding fumes, silica, man-made vitreous fibres, and other chemicals such as isocyanates, cadmium, vanadium and polycyclic 1 aromatic hydrocarbons and wood dust (HSE, 2020b). The extent to which COPD is linked to occupational exposures in construction workers reportedly depends upon whether they are smokers or not. In a study of Swedish construction workers exposed to airborne risk factors, researchers found that the percentage of COPD that was attributable to workplace risk factors was 10.7 per cent, but this increased to 52.6 per cent among occupationally exposed workers who had never smoked (Bergdahl et al., 2004). Importantly, Murgia and Gambelunghe (2021) argue that COPD is a significantly underdiagnosed disease and, even when it is diagnosed, occupational factors are often overlooked, meaning that many cases go uncompensated.

In many instances it is hard to disentangle workplace and lifestyle risk factors in illness causation. For example, work-related stress is linked to impaired sleep (Äkerstedt, 2006) which is, in turn, associated with high body mass index and obesity (Gangwisch et al., 2005; Bjorvatn et al., 2007). Poor sleep is also an identified risk factor for cardiovascular disease and diabetes (Spiegel et al., 2005; Gangwisch et al., 2006; Gottlieb et al., 2006). Thus, work-related stress (an occupational risk factor) can contribute in complex ways to illnesses typically considered to be associated with living an unhealthy lifestyle. Similarly, it is widely reported that workplace exposures can "potentiate" the effect of smoking (a lifestyle health risk). A great deal of research has focused on the combined risks of asbestos exposure and smoking, with research finding that non-smokers' exposure to asbestos, or smoking without being exposed to asbestos are both linked to increased lung cancer mortality. However, when taken together, exposure to asbestos and smoking have an interactive effect resulting in a substantially increased incidence of lung cancer mortality (Markowitz et al., 2013; Frost et al., 2011). Similar patterns in the occurrence of lung disease have been found when tobacco smoking is combined with exposure to wood dust in the workplace (Barcenas et al., 2005).

O'Neill et al. (2007) highlight the complex challenges in managing workers' exposures to hazardous substances when workers can be exposed to multiple (and interacting) health hazards at the same time, as well as changing exposures over their working lives. Simultaneous exposure to different occupational hazards or environmental conditions can substantially increase the likelihood of harm. For example, exposure to airborne pollutants (including working in a dusty environment) can negatively affect workers' innate lung defence mechanisms (known as the mucociliary clearance system) enabling other harmful airborne substances to enter the body more easily (O'Neill et al., 2007). O'Neill et al. (2007) argue that current exposure standards and risk control regimes do not adequately reflect these interactive effects or the complexity of exposures to occupational health hazards.

2.4 Deciding on appropriate risk controls for occupational health hazards

Notwithstanding these complexities, occupational health and safety legislation establishes the same responsibilities for managing risks to workers' health as those that apply to managing safety risks. In countries that have adopted the UK model of Robens-style occupational health and safety legislation, employers and others have general duties to eliminate hazards or, where this is not possible, to reduce risk so far as is reasonably practicable.

Within this regulatory framework, the concept of the hierarchy of control (HoC) is used to inform decision-making about how to control health (and safety) risks in a given situation. The HoC arranges occupational health risk controls in a descending order of effectiveness based on the understanding that making the work environment safer and healthier is more effective than trying to change the behaviour of workers. The levels of the HoC are:

- elimination: this is the most effective form of control because the elimination of a hazard poses no risk to workers or the public;
- substitution: this involves replacing the hazard with a less harmful alternative;
- engineering controls: these isolate or separate people from hazards;
- administrative controls: these include measures designed to change the way workers undertake a task;
- personal protective equipment (PPE): this is generally regarded as the least effective control measure as it relies on the individual to use it.

Although much emphasised and visible on a worksite, it is widely understood that PPE should always be seen as a "last resort" and always supplemented with higher level controls in the hierarchy.

Example controls for the risk of exposure to diesel exhaust emissions are shown in Table 2.1 below. Diesel exhaust is classified by the International Agency for Research on Cancer (IARC) as definitely carcinogenic to humans. Diesel exhaust emissions are made up of gaseous components and particulate matter, each of which can have health effects on their own but which, in combination, are known to produce complicated effects on the cardiovascular, respiratory and neurological systems, as well as causing cancer (Landwehr et al., 2021). Diesel exhaust is a problem in construction and has been linked to lung function decline in tunnel workers (Bakke et al., 2004) and lung cancer mortality in truck drivers (Järvholm & Silverman, 2003). It is therefore widely recommended that diesel exhaust emissions be eliminated or, at least, reduced as far as possible.

Occupational exposure limits have been established for diesel exhaust. For example, the Australian Institute of Occupational Hygienists recommends an

TABLE 2.1 Example hierarchy of control for diesel exhaust emission

Risk control classification	*Example control measure*
Elimination	• Replace diesel-powered plants with electrically driven, propane, compressed natural gas or petrol-fuelled vehicles
Substitution	• Use lower diesel emission engines/cleaner fuels (e.g., low sulphur diesel) or more fuel-efficient engines
Engineering controls	• Install engine exhaust filters • Install a local tailpipe exhaust ventilation • Install other ventilation techniques such as dilution ventilations or local extraction ventilation • Use other ventilation, such as exhaust gas recirculation, catalytic converters or selective non-catalytic reduction • Use diesel emissions "after treatment" systems • Fit exhaust gas recirculation systems • Use enclosed cabins in vehicles with filtered air • Provide fresh air by using controls like a canopy air curtain • Separate areas in which diesel engines are operating
Administrative controls	• Reduce the number of employees directly exposed and their period of exposure (e.g., through rotation or work schedules) • Prohibit/restrict unnecessary idling of engines • Restrict the total engine horsepower and number of diesel-powered equipment in defined areas • Allocate areas without any diesel engine operation and personnel travel • Set up speed limits and put one-way traffic routes into place to reduce the level of traffic • Perform regular maintenance of all diesel-powered machines and equipment • Perform annual training for workers • Perform routine cleaning or replacement of air filters, regular tuning of the engine • Monitor emissions and record backpressure on exhaust treatment devices at each routine service
PPE	• Use respiratory protective equipment

Source: RMIT University, 2018.

exposure limit of 100 micrograms (μg) per cubic metre (measured as elemental carbon) as a time-weighted average over 8 hours (AIOH, 2017). However, Landwehr et al. (2021) argue that this level is still too high for an occupational exposure standard because it does not take into account workers with asthma or allergies and is well above diesel exhaust concentrations in studies that found an elevated risk of lung cancer.

2.5 Occupational cancer

Construction workers are at significant risk of occupational cancer. A UK study of the burden of occupational cancer found that approximately 8,000 cancer deaths (in 2005) and 13,500 cancer registrations (in 2004) in Great Britain could be attributed to occupational exposure (HSE, 2020c). The study estimated the proportion of cancer cases associated with exposure to substances identified by the International Agency for Research on Cancer as either known (Group 1) or probable (Group 2A) carcinogens.

Figure 2.1 shows occupational cancer deaths arising from exposure to the top ten carcinogens in 2005 compared to 2014–18 (based on annual average estimates). The majority of occupational cancer deaths were attributed to exposure to asbestos and these deaths increased between 2005 and 2014–18. Other major contributors to occupational cancer death were exposures to silica and diesel engine exhaust.

The HSE (2020c) reports that construction workers were proportionally more likely to experience occupational cancer than workers from any other industry. Construction workers accounted for more than 40 per cent of occupational cancer deaths in 2005. Due to the long latency period of occupational cancers, past exposures to asbestos and silica were the predominant causes of death from

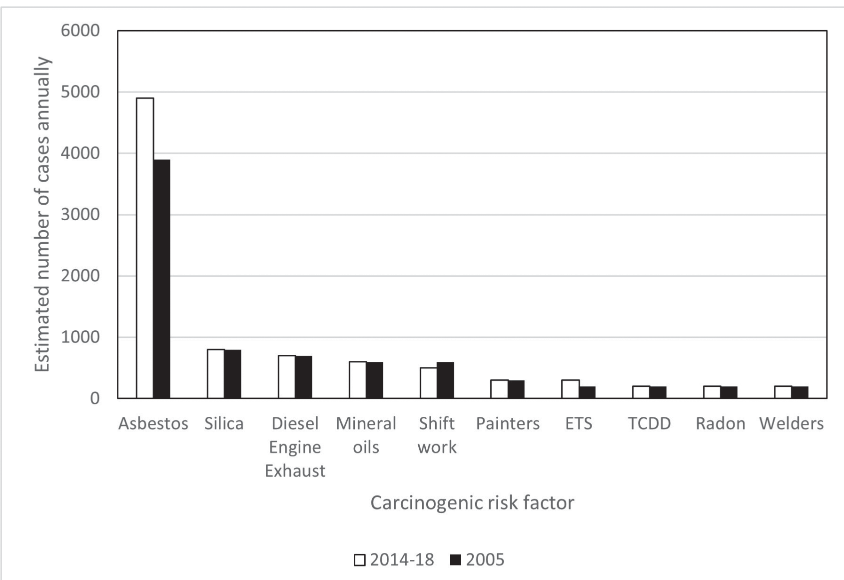

FIGURE 2.1 Carcinogens associated with occupational cancer deaths in the UK

Note: ETS – Environmental Tobacco Smoke, TCDD – 2,3,7,8-Tetrachlorodibenzodioxin.

Source: HSE, 2020c.

lung cancer and mesothelioma. Mesothelioma is most commonly experienced by carpenters, plumbers and electricians. The HSE (2020a) reports that 17 per cent of mesothelioma cases are related to past asbestos exposure in carpentry and, in particular, the use of insulation board containing brown asbestos in building construction. In a study of lung cancer mortality in the USA, Dement et al. (2020) found that the risk of lung cancer death associated with spending five years in construction was comparable to known risk factors of having a personal cancer history, a family history of cancer or a diagnosis of COPD. Dement et al. (2020) analysed a large sample longitudinal data set to show that, by including occupational exposures in modelling construction workers' lung cancer mortality, they were able to identify 86 per cent of participants who would eventually die from lung cancer, compared with only 51 per cent when considering only workers' age and smoking history.

Exposure to solar radiation was also commonly identified as a risk factor for painters and decorators and exposure to coal tar and pitches was identified as a risk factor for roofers, road surfacers, roadmen and paviors in new cancer registrations recorded in 2004 (HSE, 2020c). The HSE study also reported that, although deaths attributed to asbestos exposure would begin to decline after 2020 in the UK, the construction industry would continue to experience the largest number of occupational cancer cases in the future. Projected estimates suggest silica, diesel engine exhaust, solar radiation, shiftwork and working as painters and welders will be linked to the majority of occupational cancer cases among UK construction workers in the future. The link between shiftwork and occupational cancer is noteworthy and related to working time arrangements discussed in Chapter 4 of this book.

Case example 2.1 highlights the importance of taking a global approach to the management of occupational cancer risks.

CASE EXAMPLE 2.1 GLOBAL INTERVENTIONS TO IMPROVE OCCUPATIONAL HEALTH: THE CASE OF ASBESTOS

The importance of a global response to the management of occupational cancer risks is highlighted by the case of asbestos. Asbestos accounts for approximately half of the world's occupational cancer deaths and cancer risk is reported even when workers are exposed to very low levels of asbestos (WHO, 2014).

The World Health Organization (2014) reports that 90 per cent of chrysotile asbestos is used in cement building materials, which is a particular problem because the size of the global construction workforce means that large numbers of people are exposed. It can also be hard to control exposure to airborne contaminants in construction workplaces and exposures can also increase as building materials are damaged or deteriorate over time (WHO, 2014).

According to the World Health Organization (2014), approximately 125 million people in the world remain exposed to asbestos at the workplace and at least 107,000 people die each year from occupational lung cancer, mesothelioma and asbestosis caused by exposure to asbestos at work.

International efforts have been made to eliminate asbestos-related diseases. For example, the International Labour Organization (ILO) Convention no 162 concerning Safety in the Use of Asbestos focused on prevention of occupational exposure to asbestos and established the principle of ensuring workers' exposure to asbestos remains below a specific limit (Lin et al., 2019). Subsequently, in 2003, the Thirteenth Session of the Joint International Labour Organization (ILO)/World Health Organization (WHO) Committee on Occupational Health recommended special attention be paid to the elimination of asbestos-related diseases and, in 2007, the World Health Assembly called for global campaigns to eliminate asbestos-related diseases. Lin et al. (2019) studied the effectiveness and impact of international initiatives and found that individual countries' adoption of international Conventions relating to the reduction of asbestos-related harm play an important role in facilitating the implementation of total asbestos bans in countries around the world, highlighting the importance and effectiveness of international programmes and agreements.

The World Health Organization report on chrysotile asbestos (the most widespread form of asbestos in use globally) states that "the most efficient way to eliminate asbestos-related diseases is to stop the use of all types of asbestos." The WHO is also committed to working with individual countries to reduce the burden of asbestos-related illness and death by: "providing information about solutions for replacing asbestos with safer substitutes and developing economic and technological mechanisms to stimulate its replacement, taking measures to prevent exposure to asbestos in place and during asbestos removal (abatement), improving early diagnosis, treatment and rehabilitation services for asbestos-related diseases and establishing registries of people with past and/or current exposure to asbestos" (WHO, 2014, p.4).

The manufacture and use of all types of asbestos have been banned in some 68 countries. However, workers in countries in which asbestos has been banned from use can still be exposed as a result of historical use of asbestos products in existing buildings (for example, during renovation, maintenance or demolition). In the context of global supply networks for building products it is also difficult to ensure that imported products do not contain asbestos. Australian trade union organisations recently called for a global ban on the use of asbestos when it was found in a number of imported materials and products in use in the Australian construction industry (Australian Broadcasting Corporation, 2021).

Asbestos is still widely used in many countries in the world. The World Health Organization observes the use of asbestos is still common in many developing countries and in the Asia Pacific region. However, the OECD countries of Mexico and the United States have also not yet banned the use of asbestos.

Importantly, because of the long latency period between exposure and illness, even if asbestos production and use completely stopped everywhere in the world now, the global burden of asbestos-related illness and death would still not decline for several decades (WHO, 2014).

The case of asbestos illustrates how difficult it is to prevent exposure to harmful substances, even when they are irrefutably linked to fatal illnesses such as occupational cancers.

2.6 Exposure to respirable silica

In 1930, a landmark International Labour Organization (ILO) conference held in Johannesburg highlighted the health risks associated with being exposed to and inhaling particles of respirable crystalline silica (Sauvé, 2015). However, a broad awareness of the extent and impacts associated with exposure to respirable silica in the construction industry did not develop until as late as the 1990s (Sauvé, 2015). It is now widely recognised that construction workers are a high-risk group for health problems associated with exposure to respirable silica. For example, a World Health Organization project investigating the Global Burden of Disease found that after mining (23%), construction has the second highest percentage of workers exposed to silica (19%) (Driscoll et al., 2004).

Exposure to respirable crystalline silica can cause silicosis, which is an irreversible, fibrotic lung disease caused by the inhalation of respirable crystalline silica. Silicosis is a progressive and potentially lethal disease that constitutes a major public health issue around the world (Hoy et al., 2021). Exposure to respirable crystalline silica is also associated with increased risk for lung infection (e.g., tuberculosis), lung cancer, emphysema, autoimmune diseases, and kidney disease (Nij & Heederik, 2005).

In 1997, crystalline silica was classified as a carcinogen for humans by the International Agency for Research on Cancer (Nij & Heederik, 2005). Hoy et al. (2021) observe that, although occupational exposure limits (OELs) for crystalline silica have been established in many regions of the world, the extent to which they protect workers is limited due to inconsistency – in some low and middle-income countries there is no legislated exposure limit, and OELs established in other areas are often in excess of the recommendation of the American Conference of Governmental Industrial Hygienists of an OEL for respirable crystalline silica of 0.025 mg/m^3. Moreover, even when OELs are established by legislation, compliance with these levels is hindered by low levels of surveillance and enforcement (Hoy et al., 2021). Indeed, research shows that exposure to respirable crystalline silica in the construction industry frequently exceeds established OELs (Flanagan et al., 2003; Akbar-Khanzadeh & Brillhart, 2002; Nij et al., 2003; van Deurssen et al., 2014). One US study suggests that overexposure of construction workers to respirable crystalline silica ranges between 65 and 100 per cent (Rappaport et al., 2003)

The International Labour Organization (ILO)/World Health Organization (WHO) Global Program for the Elimination of Silicosis was established in 1995 and focuses on both primary and secondary control of respirable crystalline silica exposure. While secondary prevention focuses on surveillance of the work environment and of workers, primary prevention seeks to eliminate or reduce silica dust at the source (Beaucham et al., 2012). Although primary prevention controls are available, it is widely reported that respiratory protective equipment is the most widely used form of risk control adopted to prevent harm associated with respirable crystalline silica exposure, which may not be sufficient in the absence of other forms of control (Nij et al., 2003). This is in spite of evidence that dust emissions can be substantially reduced through the use of control measures such as the use of local exhaust ventilation systems (Akbar-Khanzadeh & Brillhart, 2002) or wet dust suppression when undertaking high-risk work tasks such as cutting concrete (Summers & Parmigiani, 2015). Importantly, though, the efficacy of control measures in workplace settings can also be impacted by organisational and psychosocial factors, and measures designed to reduce exposures to respirable crystalline silica should take account of barriers to adoption in the work environment (van Deurseen et al., 2014).

One of the challenges associated with managing the risk of exposure to respirable crystalline silica in construction workplaces is that the construction workforce is not homogeneous and exposures vary depending on tasks performed, environmental conditions and tools and materials used (Nij et al., 2004). For this reason, task-based hazard and potential exposure analysis needs to be used to determine appropriate controls.

Importantly, although exposure to respirable crystalline silica is an "ancient" occupational health problem in the construction industry, workers are also affected by emergent risks (Hoy et al., 2018). One such case is the use of engineered stone which has, in recent years, become increasingly fashionable in the construction of stone benchtops in kitchens and bathrooms.

Case example 2.2 considers the use of engineered stone, the harm associated with the use of this product, and how this harm can be managed.

CASE EXAMPLE 2.2 TO BAN OR NOT TO BAN? THE CASE OF ENGINEERED STONE

Safe Work Australia (2021) defines engineered stone as material that "is (a) created by combining and heat curing natural stone materials that contain crystalline silica (such as quartz or stone aggregate) with chemical constituents (such as water, resins or pigments), and (b) can be manipulated through mechanical processes to manufacture other products (such as kitchen benchtops)" (p.6).

Compared to natural stone, engineered stone contains more silica – potentially up to 97 per cent compared to up to 45 per cent for granite (Safe Work Australia, 2021). Higher levels of crystalline silica in engineered stone substantially increase health risks to workers (for example, cutting, grinding, trimming, drilling, sanding and polishing engineered stone). These processes generate respirable dust containing crystalline silica which, when breathed in over time, can cause fatal lung disease (Safe Work Australia, 2021).

Recent analyses of silicosis risk among stone fabrication workers have revealed "outbreaks" of silicosis among workers who work with engineered stone (ABC, 2019). For example, following screening of 659 stonemasons who work with engineered stone in Queensland Australia, 21.4 per cent (141 of 659) were diagnosed with silicosis (Newbigin et al., 2019). In the first year of a health screening programme in Victoria, 86 (36 per cent) of 239 screened stonemasons were diagnosed with silicosis (Hoy et al., 2021). The average age of these workers was 41.8 years and 72 of the 86 were employed in the stone benchtop industry at the time of diagnosis. The others indicated they were no longer working in the industry at the time of diagnosis (Hoy et al., 2021). Hoy et al. (2021) compare the 86 cases identified over a 12-month period to the average of 8 silicosis compensation claims per year in Victoria for the 10 years prior to the health-screening study.

Studies of silicosis attributable to exposure to engineered stone report a short latency period, accelerated occurrence of extensive lung damage and experience of illness in relatively young workers (Leso et al., 2019; Hoy et al., 2021). These characteristics are explained by the high levels of respirable dust generated in some activities and the intensity of exposure (Hoy et al., 2018). Leso et al. (2019) also identify the possibility that dusts produced when working with engineered stone may have specific properties due to the combination of crushed rock and polymeric resins, which potentially increase toxicity and occupational health risk.

León-Jiménez et al. (2020) report an accelerated decline in lung function and a rapid progression to progressive massive fibrosis (PMF) in a sample of Spanish construction workers exposed to silica from engineered stone. Initially (at diagnosis) 6.6 per cent of cases were classified as having PMF but, after cessation of exposure, this rose to 37.7 per cent over a four-year follow-up period (León-Jiménez et al., 2020). A more rapid deterioration in lung function was also observed in silicosis cases associated with engineered stone (León-Jiménez et al., 2020). Thus, silicosis associated with engineered stone appears aggressive compared to silicosis arising as a result of exposure to natural stone.

A retrospective Australian study was conducted of 78 stonemasons diagnosed by their treating respiratory physicians as suffering from either accelerated (*n* = 36) or chronic (*n* = 42) silicosis focused on the presence of occupational risk factors, i.e., whether a person (i) worked with artificial stone products for >50% of their total tenure; (ii) used personal protective equipment (PPE) for <50% of their total tenure; and/or (iii) performed >50% of their work using dry-cutting techniques (Newbigin et al., 2019). The average age of the stonemasons was 34.1 years (range: 23–63) and their average tenure in stonemasonry was 12.9 years (range: 2–45). Most of the stonemasons (68%) reported all three occupational risk factors. All participants indicated the presence of at least one risk factor and 87% indicated they performed more than half of their work using a dry-cutting method (Newbigin et al., 2019). This is consistent with the review of international research undertaken by Leso et al. (2019) which showed that basic preventive measures for controlling occupational exposure (e.g., general or mounted-tool local exhaust ventilation systems or wet-cut methods to suppress dust) were not in place or not implemented properly and full/suitable protective equipment was either not available or not used correctly.

Rose et al. (2019) also report the majority of stone fabrication workers diagnosed with silicosis in the USA were migrant (Hispanic) workers, many of whom worked in small businesses in which low levels of safety awareness, a lack of expertise and low levels of investment in exposure-control technologies substantially increase health risks.

Engineered stone has been compared to asbestos (Fritschi & Reid, 2019). Several Australian organisations (including unions, the Cancer Council, the Thoracic Society of Australia & New Zealand, Lung Foundation Australia, the Australian Institute of Health and Safety, the Public Health Association of Australia and the Australian and New Zealand Society of Occupational Medicine) have supported a ban on the manufacture and use of high silica engineered stone (Fellner, 2021). Fritschi and Reid (2019) point out that alternative (silica-free) products are available for use (e.g., Betta Stone, an environmentally sustainable countertop material made from recycled glass).

However, industry and government stakeholders argue that the danger associated with engineered stone products can be managed through the implementation of effective risk controls within workplaces. This is reflected in recent legislative changes in New South Wales, Queensland and Victoria. As of 2019, in Victoria, employers, self-employed people or people who manage or control a workplace must ensure a power tool is not used to cut, grind or abrasively polish engineered stone, unless the tool: (i) has an integrated water delivery system that supplies a continuous feed of water (on-tool water suppression), or (ii) is fitted with on-tool extraction attached to a HEPA filtered dust class H vacuum cleaner (or similar system that captures the dust generated). If these controls are not reasonably practicable, the use of power tools must be controlled through local exhaust ventilation (LEV). In Victoria, people cutting, grinding or polishing engineered stone with a power tool must also be provided with respiratory protective equipment that: (i) is designed to protect the wearer from the inhalation of airborne contaminants entering the nose, mouth and lungs; and (ii) complies with AS/NZS 1716 – Respiratory protective devices.

However, the efficacy of these control measures has been questioned, with the Australian Cancer Council suggesting they are unlikely to be rigorously implemented in small workplaces. Further, wet cutting alone may not reduce respirable crystalline silica (RCS) levels to safe levels. For example, an international study found dry cutting of engineered stone to generate an RCS concentration of 44.6 milligrams per cubic metre (mg/m^3) over 30 minutes of sampling. This decreased to 4.85 mg/m^3 when wet blade cutting was used and to 0.69 mg/m^3 when wet blade cutting was combined with local exhaust ventilation (Cooper et al., 2015).

To put these concentration levels into perspective, in its recent Code of Practice on managing the risks of RCS in the use of engineered stone, Safe Work Australia established an eight-hour time-weighted average (TWA) exposure standard for RCS of 0.05 mg/m^3 (Safe Work Australia, 2021).[1] It is also reported that short-term exposure to concentrations of RCS above 2 mg/m^3 is proportionally more risky than longer-term cumulative exposures at lower concentrations (Buchanan et al., 2003). This means that wet blade cutting, without local exhaust ventilation, may still put workers at considerable risk. Hoy et al. (2018) therefore argue that eight-hour standards do not provide adequate guidance concerning the risk posed by short-duration but high-intensity exposure to RCS.

As with all occupational health hazards, it is critical that the most effective controls available are selected based upon the previously described hierarchy of control. Table 2.2 classifies example controls for the risk of airborne contaminants according to their position in the hierarchy.

2.7 Occupational hearing loss

Unlike many dust-related diseases, hearing loss does not result in early mortality. The loss of hearing, however, is a serious disability which can contribute to social isolation, reduced confidence, poor mental health and declining cognitive

TABLE 2.2 Example control measures for airborne health hazards in construction

Risk control classification	*Risk control*
Elimination	• eliminate airborne hazards (however, this is often not possible especially when working with sand/concrete, when undertaking tunnelling activities or when removing asbestos)
Substitution	• use garnet as a substitute for sand • use aluminium oxide polishing powders instead of silica powders • use pilled solids instead of powders • use wet processes instead of dry processes • vacuum instead of sweep
Engineering controls	• implement barrier protections at the entrance to the working area • use ventilation systems (local exhaust ventilation systems are available such as enclosing hoods, high-velocity low-volume hoods and exterior hoods) • use industrial vacuum cleaners • use water or fine mist suppression to control dust cloud (additional water dust suppression should be applied for tasks which are outside during dry weather or to control dust in mines) • install a conveyor belt wash box where conveyor belts are in use • implement dampeners to increase the air flow • provide fresh air by using controls like a canopy air curtain to cover roof bolters operators and enclosed cabin filtration systems • use sticky floor mats to reduce the amount of dust or debris transferred to other working areas • use thickened substances such as pastes and gels to cover the surfaces being worked on
Administrative controls	• maintain good housekeeping and signage • restrict time of exposure • do not perform dust-generating tasks, such as dry brush sweeping, and the use of compressed air or reuse of vacuum filters • do not carry out dust-generating work on high wind days • reduce the time spent in the dusty areas by job rotation • train the workers how to use PPE correctly and which PPE is appropriate for the task • inform workers about risk of exposures and instruct them how to protect themselves • conduct health monitoring regularly • forbid drinking, eating and smoking while working in areas where asbestos may occur • remove disposable shoe covers or overalls before leaving the working area (if covers aren't used, contaminated shoes and clothing should be cleaned before leaving)

TABLE 2.2 Cont.

Risk control classification	*Risk control*
	• provide washing facilities as close as possible to the working area, including mild skin cleansers and clean soft paper or towels for drying • encourage workers to wash areas of their skin which might have been exposed and to use pre-work creams, if necessary, before starting work or after a break • avoid dust-generating activities on high wind days when working outdoors • remove construction debris through an approved route, if possible during off-peak times (the debris should be covered and netted when removed) • conduct health monitoring including a physical examination of the worker with a focus on the respiratory system • conduct additional training or awareness programmes to increase workers' understanding of the risk with a specific task, environment or material-related activity
PPE	• provide appropriate filters for workers (P1 filters are for mechanically generated particulates like silica or asbestos, P2 filters are for thermally and mechanically generated particulates like metal fumes, P3 requires a full-face mask and can be used for all particulates including highly toxic materials like beryllium) • provide coveralls, respiratory protective equipment, footwear and gloves in addition to other control measures, when working with asbestos • provide hand protection creams • use closed eye goggles for any kind of overhead or demolition work

Source: RMIT University, 2018.

function (Chen et al., 2020; Lewkowski et al., 2019). Nelson et al. (2005) report that 16 per cent of disabling hearing loss experienced by adults worldwide is attributed to exposure to noise at work (Nelson et al., 2005).

Noise-induced hearing loss (NIHL) is one of the most frequently experienced occupational diseases among construction workers (van der Molen et al., 2016). NIHL is reported to have a high prevalence among construction workers. For example, NIHL is experienced by 15% of construction workers in the Netherlands (Leensen et al., 2011), 37% in Australia (Kurmis & Apps, 2007) and between 23% and 58% in the USA (Masterson et al., 2013; Dement et al., 2018). However, the definition of NIHL varies from country to country, making direct comparisons difficult (Lie et al., 2016). Research in the USA shows that, although the general all-industry incidence of NIHL is reported to be reducing, the percentage of workers affected by NIHL remains high in construction (Masterson et al., 2015).

Also, Chen (2020) observe that NIHL is more prevalent in developing countries, suggesting that the global problem may be more significant than is reflected by studies conducted in Europe, the USA and Australia.

In many countries, standard exposure levels for noise have been established. For example, in the USA the Occupational Safety and Health Administration establishes a permissible exposure limit of 90 dBA for an eight-hour time-weighted average (TWA) with a 5 decibel (dB) exchange rate and an action level of 85 dBA for an eight-hour TWA. A hearing conservation programme must be implemented for workers whose exposure to noise is equal to or exceeds this action level. The National Institute for Occupational Health and Safety's (NIOSH) recommended exposure limit (REL) is 85 dBA with a 3 dB exchange rate. The exchange rate refers to the number of dB increases at which the allowable exposure time is halved (Chen et al., 2020).

However, heavy machinery and equipment, transport vehicles, power and hand tools used in construction often produce noise levels that exceed recommended or maximum permissible exposure limits (Hong, 2005). Evidence suggests that, in many cases, construction workers continue to be exposed to noise levels in excess of exposure standards. For example, a large study of construction work practices in the USA found that construction workers were exposed to noise levels that exceeded the NIOSH REL in three-quarters of the work shifts for which full-shift measurements of noise exposure were available (Neitzel et al., 2011). Ironworkers had the highest exposure and insulation workers had the lowest exposure to occupational noise but, importantly, seven of the eight trades included in the study recorded average exposures that exceeded the REL for noise (Nietzel et al., 2011).

In Australia, Lewkowski et al. (2018) developed a questionnaire-algorithm to identify construction workers who are exposed to noise levels that exceed the Australian National Standard for Occupational Noise (an $L_{Aeq,8h}$ of 85 dBA or above). The questionnaire captured information about an individual's work activities, use of noise reduction methods, background environment and shift length. This data is then cross-referenced with a database containing task-based measures of noise taken from previous studies. Questionnaire-derived noise exposure estimates for 100 construction workers were compared to exposure data captured by a personal noise dosimeter over a whole work shift. The questionnaire method demonstrated an excellent ability to estimate whether a worker had exceeded the national standard exposure level over their shift, suggesting it is a useful way to understand exposure to noise in complex environments, such as construction sites (Lewkoswki et al., 2018).

There is strong and consistent evidence that, compared to other workers who are not exposed to high levels of occupational noise, construction workers are a high-risk group for NIHL. In the Netherlands, construction workers exposed to site-based noise were found to have significantly greater hearing loss than a comparison group of workers who were not noise exposed, i.e. those that had office-based jobs (Leensen et al., 2011). Leensen et al. (2011) found noise exposure to be a stronger predictor of NIHL than noise intensity and, in a follow-up longitudinal analysis of construction workers' hearing threshold levels, an average annual deterioration in hearing of 0.54 dB per year was observed (Leensen et al., 2015). This deterioration was larger with increasing noise exposure. Similarly, in the USA, Dement et al. (2005) examined health surveillance data and found that construction trade workers engaged at Department of Energy nuclear sites were at substantially higher risk of material hearing impairment than workers in an external population with jobs in which noise exposure is <80 dBA, when controlling for age-related effects. For the purpose of this analysis, material hearing impairment was defined in accordance with NIOSH guidelines, i.e., a "biaural average threshold greater than 25 dB calculated as the articulation index weighted average across frequencies of 1, 2, 3, and 4 kHz" (Dement et al., 2005, p.350). The odds of construction workers experiencing material hearing impairment increased more than two-fold with exposure to loud or very loud noise between 50% and 69% of the time, in comparison to workers exposed to loud or very loud noise less than 50% of the time. Construction workers exposed to loud or very loud noise for more than 70% of the time were 2.7 times more likely to experience material hearing impairment. A longitudinal study of noise exposure and hearing damage in construction apprentices in the USA also revealed changes in hearing thresholds associated with noise exposure over a ten-year period (Seixas et al., 2012). These changes were greater than expected. Seixas et al. (2012) suggest this may be explained by the fact that the apprentices already had a degree of hearing loss at the outset of the study and were, therefore, potentially more susceptible to further noise-related hearing decline. The implication of this finding is that programmes to prevent NIHL need to be implemented early in the working lives of construction workers as exposure to work and recreational noise levels can affect hearing thresholds at an early age.

The important point to note is that NIHL is irreversible but preventable. For example, Dement et al. (2005) point to programmes implemented in Sweden and Canada that have effectively implemented hearing protection programmes that reduced the percentage of construction workers with NIHL. Key activities in the prevention of NIHL include monitoring noise exposure levels in the workplace and implementing appropriate risk controls.

Daniell et al. (2006) considered the scope and effectiveness of hearing protection programmes across a number of high-risk industries in the USA, including road construction. Hearing loss prevention programmes were found to be incomplete across all industries included in the study. While most companies conducted noise measurements, records were not typically kept and there was little management consideration of ways to control noise (Daniell et al., 2006).

Many hearing protection programmes implemented in construction still focus heavily on the use of hearing protection devices (HPDs) (Daniell et al., 2006). Though important in noisy settings, HPD provision and use should be seen as a secondary protection measure because HPDs are only effective to the extent that they are used correctly in all appropriate situations (Chen et al., 2020). In fact, self-reported use of HPDs among construction workers is low and the extent to which they provide the advertised level of protection when used in the workplace has also been questioned. For example, Leensen et al. (2011) report that only 77% of Dutch construction workers exposed to daily noise levels exceeding 80 dB(A) report that they wear hearing protection devices (HPDs) at work, indicating that 23% of the exposed workers do not use protective equipment. Similarly, Hong (2005) found that a high-risk group of machinery operators report using HPDs for only 48% of the time they are exposed to high noise levels. Neitzel & Seixas (2005) found considerable variation between trades in terms of usage of HPDs: e.g., operating engineers spent 49% of minutes in each shift exposed to noise levels greater than 85 dBA but used HPDs for 59% of this time; ironworkers spent 38% of minutes in each shift exposed to noise levels greater than 85 dBA but used HPDs for only 9% of this time (Neitzel & Seixas, 2005). Neitzel and Seixas (2005) also undertook field tests to evaluate the attenuation achieved by ear plugs when used by construction workers. On average, more than 50% of the stated noise reduction rating was achieved for three types of ear plug. However, variability in attenuation was high, being lowest at a frequency of 500 Hz. When considering attenuation performance and use together, Neitzel and Seixas (2005) conclude that HPDs provide negligible effective protection for construction workers, reinforcing the importance of reducing the risk of NIHL through other forms of control.

As with all workplace health and safety issues, the hierarchy of control (HoC) should be applied when deciding how to control the risk of occupational noise. Thus, wherever possible, noise should be eliminated or reduced at source through substitution or engineering controls. Administrative controls, including undertaking routine audiometric examination of workers and providing education on the prevention of NIHL and the use of personal protective equipment, are also recommended (Chen et al., 2020). Most importantly, though, the risk of NIHL is reduced if noise levels are reduced to below 80 dBA.

The best way to control the risks associated with occupational noise is to eliminate noise at source or replace noisy work processes, tools or machinery with methods and equipment that produce less noise. In the USA, NIOSH implemented a programme called "Buy Quiet." The objective of this programme was to encourage businesses to purchase or hire equipment that is quieter to reduce workplace noise levels. This could either be at point of business start-up or when equipment is being replaced. To support the programme, NIOSH developed a database containing noise performance data for power tools in common use, by make and model. It was anticipated that by raising customer awareness and creating an increased demand for quiet equipment, manufacturers would be encouraged to invest effort and resources into designing equipment that produces substantially less noise.

Engineering controls can also substantially reduce noise levels associated with equipment use. For example, Saleh et al. (2017) described an experiment in which commercially available sound-dampening mats were installed between the engine compartment and cabins in three types of plant used in construction (an asphalt roller, a grader and a mobile crawler crane). Sound levels were measured before and after the installation and the results indicated that sound pressure levels could be significantly reduced by the installation of the sound-dampening mats. However, when the machinery was operating at full throttle, sound pressure levels still exceeded 80 dBA when the mats were installed.

2.8 Other factors contributing to occupational hearing loss

Although occupational hearing loss is usually understood to be related to exposure to noisy workplaces, there is also evidence that occupational hearing loss can be caused by exposure to occupational hazards other than noise, such as ototoxic chemicals and lead (Lie et al., 2016). Ototoxic chemicals include organic solvents which, when absorbed into the bloodstream, can damage the inner ear and/or the auditory nerve pathways to the brain, resulting in hearing loss and tinnitus.

Lewkowski et al. (2019) report on an Australian Workplace Exposure Survey (AWES) that focused on hearing. This survey explored Australian workers' exposure to both occupational noise and ototoxic chemicals. In order to assess exposure to ototoxic chemicals, a priority list of all substances identified as being ototoxic or possibly ototoxic was collated from multiple international databases. Next, rules were developed to classify specific work tasks as involving exposure to ototoxic chemicals. These rules were then applied to data collected during interviews with more than 5,000 Australian workers. Over half of the workers in the sample (51%) were exposed to one or more ototoxic chemicals, with 85% of those exposed at a medium or probable high level.

Co-exposure to both ototoxic chemicals and noise were examined with 80% of workers exposed to a full-shift noise level that exceeds the $L_{Aeq,8h}$ limit of 85 dBA, also being exposed to an ototoxic chemical at a medium or probable high level (Lewkowski et al., 2019). This co-exposure is concerning because there is emerging evidence to indicate that the odds of hearing loss is more than doubled for workers exposed to ototoxic chemicals and noise, compared to those just exposed to occupational noise (Choi & Kim, 2014). Among construction workers in the AWES study, 86% were exposed to ototoxic chemicals and 42% were co-exposed to ototoxic chemicals and noise exposure in excess of the $L_{Aeq,8h}$ limit of 85 dBA (Lewkowski et al., 2019). In the USA, a longitudinal study of construction workers' hearing has also linked hearing loss to exposure to both noise and organic solvents (Dement et al., 2018).

2.9 Products causing occupational skin disease

Construction workers are susceptible to occupational skin disease that can be caused by exposure to a wide variety of substances, including wet cement, epoxy resins and hardeners, acrylic sealants, bitumen or asphalt, solvents used in paints, glues or other surface coatings, petrol, diesel, oils and greases, degreasers,