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# SAFETY AND HEALTH AT THE HEART OF THE FUTURE OF WORK

Building on 100 years  
of experience





# **SAFETY AND HEALTH AT THE HEART OF THE FUTURE OF WORK**

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of experience**

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# Table of contents

Introduction .....	1
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Global trends in safety and health: The picture today .....	3
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Chapter 1: 100 years of safety and health at work .....	7
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1. Why the world needed to respond to accidents and diseases at work 100 years ago .....	7
2. The ILO: Founded on the concept of safe and healthy work .....	9
3. Post-Second World War: An increasingly global perspective on OSH .....	12
4. Towards a culture of prevention .....	20
5. ILO and safety and health at work in the new millennium .....	23

Chapter 2: A safe and healthy future of work: Challenges and opportunities .....	29
---	----

2.1 Technology .....	29
Digitalization and ICT .....	30
Automation and robotics .....	33
Nanotechnology .....	34
2.2 Demographics .....	36
Young workers .....	37
Aging worker populations .....	38
Gender .....	39
Migrant workers .....	41
2.3 Sustainable development and OSH .....	42
Climate change, air pollution and environmental degradation .....	43
The green economy .....	45
ILO instruments in relation to climate change, sustainable development and OSH .....	47

2.4 Changes in work organization .....	48
Excessive hours of work .....	49
Non-standard forms of employment .....	50
Working time arrangements .....	52
The informal economy .....	52
The example of digital labour platforms .....	53

## Chapter 3: Responding to the safety and health challenges and opportunities of the future of work ..... 55

3.1 Anticipation of new OSH risks .....	55
3.2 Multidisciplinarity in managing OSH .....	58
3.3 Building competence on OSH .....	59
3.4 Widening the horizon: The link to public health .....	60
3.5 International labour standards and other instruments on OSH .....	62
National OSH legislation and management .....	63
Governance of OSH .....	65
3.6 Reinforcing the role of governments and social partners and expanding partnerships ....	67
Concluding remarks .....	68

## References ..... 69

# Introduction

According to recent estimates released by the International Labour Organization (ILO), each year 2.78 million workers die from occupational accidents and work-related diseases (of which 2.4 million are disease-related) and an additional 374 million workers suffer from non-fatal occupational accidents. It is estimated that lost work days globally represent almost 4 per cent of the world's GDP, and in some countries, this rises to 6 per cent or more (Hämäläinen et al, 2017; Takala et al, 2014).

Aside from the economic cost, there is an intangible cost, not fully recognized in these figures, of the immeasurable human suffering caused by occupational accidents and work-related diseases. This is tragic and regrettable because, as research and practice over the past century has repeatedly demonstrated, they are largely preventable.

Psychosocial risks, work-related stress and non-communicable diseases are of growing concern for many workers in all parts of the world. At the same time, many workers remain challenged by persistent work-related safety and health risks and it is important not to overlook the workers who face these risks as we look to the future.

It is a global imperative that these challenges are addressed with effective prevention strategies. Achieving effective prevention, however, remains a major challenge in addressing global occupational safety and health (OSH).

Safety and health at work can be key to sustainable development and investment in OSH can help contribute to the achievement of the **2030 Agenda for Sustainable Development**, and especially to the achievement of **Sustainable Development Goal (SDG) 3, to ensure healthy lives and promote well-being for all at all ages** and **SDG 8, to promote inclusive and sustainable economic growth, employment and decent**

**work for all** – in particular **Target 8.8**, to protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.



Nevertheless, a considerable task remains for governments, employers, workers and other stakeholders in building present and future generations of safe and healthy workers. The ILO Global strategy on occupational safety and health, adopted in 2003, provides a framework for these activities. Crucially, the global burden of occupational accidents, work-related diseases and deaths, is a significant contributor to the growing global issue of non-communicable and chronic diseases.

When we look to the future of safety and health at work, we should also take stock of the developments in the past century. During the last 100 years, addressing occupational accidents, work-related diseases and deaths has been increasingly recognized as a major international challenge relevant to achieving social justice and sustainable development.

It is now widely acknowledged that important OSH gains can be made from improving and sharing knowledge and experience concerning the extent, causes and prevention of harm arising from work and how worker health and wellbeing can be better supported. It is also understood that, while there are enormous national and regional differences in the ways in which workplace hazards and risks are experienced, there is nevertheless much in common with regard to the principles of prevention and control of their harmful effects.

Addressing work-related hazards and risks as though they exist solely within a workplace or within national boundaries is an ineffective and incomplete strategy. Within global supply chains, both production and workers, and thus OSH risks, relocate across national borders. This necessitates global perspectives and better understandings of the interrelationship between the physical science and engineering of safe work and the medical understandings of disease and injuries, as well as the economic, regulatory and sociological understandings of the contexts that contribute to making work safe and good for health.

As the ILO celebrates its centenary, the first chapter of this report takes a look back on the evolution of these understandings over the past century and the ILO's role in its development since it was founded in 1919.

Against the backdrop of the challenge of safety and health at work, the second chapter of the report considers the trends driving change in the world of work and their impact on safety and health at work. **Chapter 2** focuses on four main ways in which the world of work is changing – covering technology, demographics, sustainable development including climate change and changes in work organization. From each of the major developments the report seeks to identify the key opportunities and challenges for OSH and for risk prevention and control.

**Chapter 3** of the report then reflects on ways that OSH is evolving and rising to the challenge of ensuring a safe and healthy future of work for all.





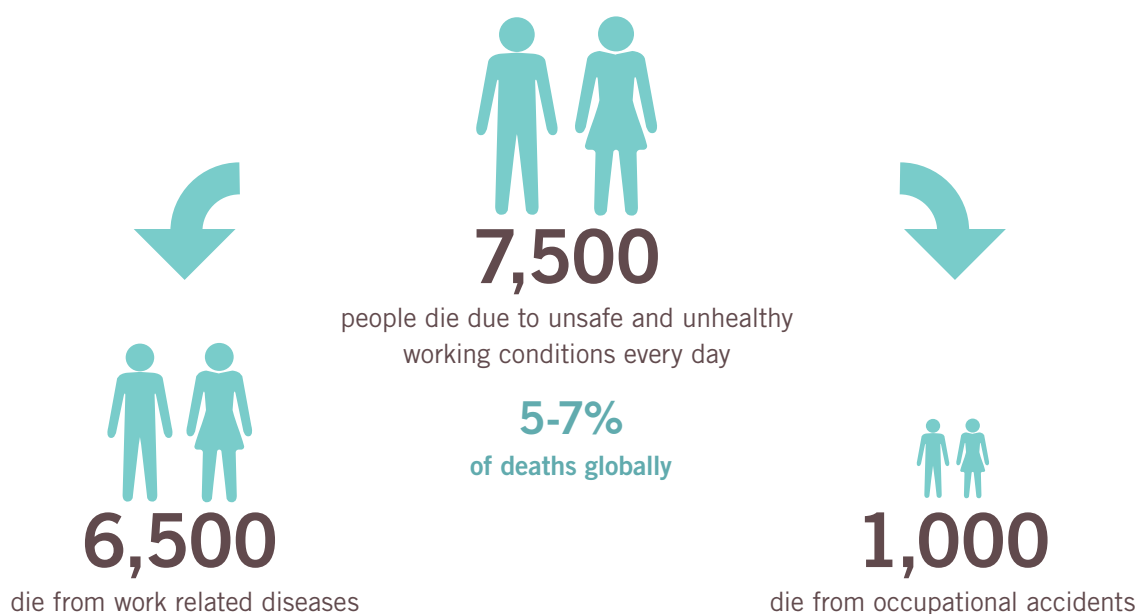
## ■ Global trends in safety and health: The picture today

Occupational accidents and work-related diseases have a major impact on individuals and their families, not only in economic terms, but also in terms of their physical and emotional wellbeing in the short- and long-term. Furthermore, they can have major effects on enterprises, affecting productivity, leading to potential disruptions of production processes, hampering competitiveness and reputation of enterprises along supply chains, and impacting on the economy and society more widely.

Although the importance of improving safety and health at work is increasingly widely recognized, providing an accurate picture of its global scale remains difficult. The systematic collection and analysis of reliable and comparable data have varied both geographically and over time, which means that comparing trends and data is challenging. In addition, even in countries with the longest and most well-established data collection systems, under-reporting, particularly of non-fatal occupational accidents and especially work-related diseases, is common (Rushton et al, 2017, Takala et al, 2017). It is critical that countries establish effective OSH data collection systems, as to improve the collection and utilization of reliable OSH data for reporting and analysis.

Nevertheless, the latest figures and estimates indicate a huge problem. Globally 1,000 people are estimated to die every day from occupational accidents and a further 6,500 from work-related diseases. The aggregate figures indicate an overall increase in the number of deaths attributed to work: from 2.33 million deaths in 2014 to 2.78 million deaths in 2017 (Hämäläinen et al, 2017).

Estimates suggest that circulatory system diseases (31 per cent), work-related cancers (26 per cent) and respiratory diseases (17 per cent) contribute to almost three-quarters of the total work-related mortality. Diseases are the cause of the great majority of work-related deaths (2.4 million deaths or 86.3 per cent), in comparison to fatal occupational accidents (which make up the remaining 13.7 per cent). Together, these account for 5 to 7 per cent of deaths globally (Christopher and Murray, 2016; ILO, 2006; Murray and Lopez, 1996).



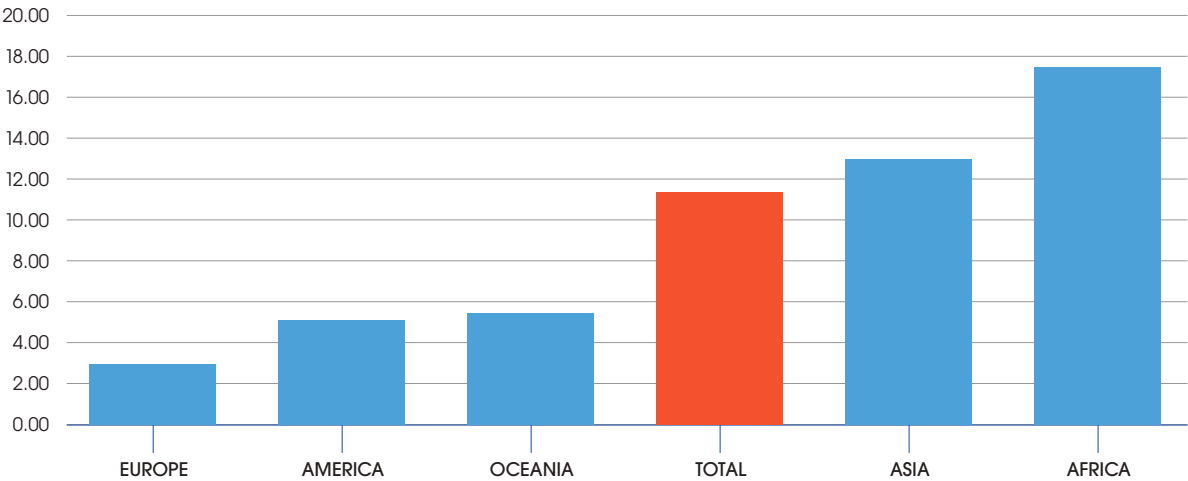
In addition, the most recent estimates from the WHO show that when accounting for both deaths and disability, the fraction of the global disease burden in the general population due to occupation amounts to 2.7 per cent (WHO, 2018).

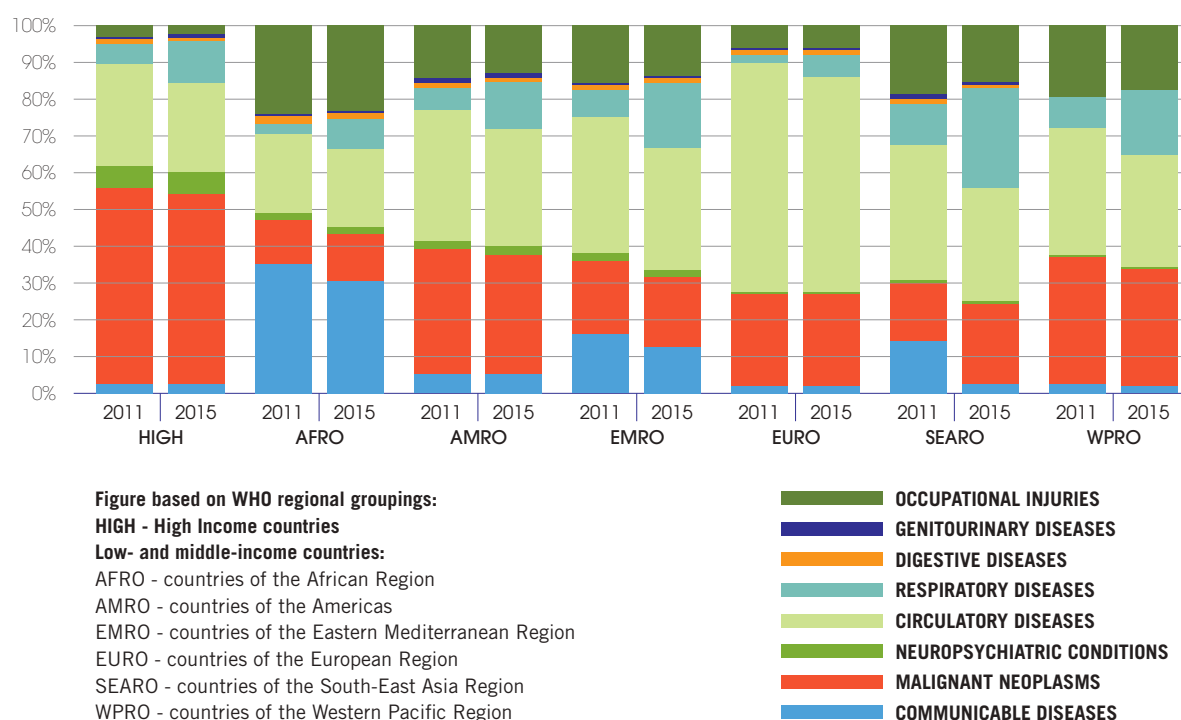
Most recent figures suggest that ergonomic factors, injury risk factors, particulate matter, gases, fumes and noise make the largest contributions to the total global burden of occupational disease (Driscoll, 2018). There is also some evidence that the relative contributions of various occupational risk factors are changing. Of 18 exposures measured in the Global Burden of Disease Survey 2016, only occupational exposure to asbestos had fallen between 1990 and 2016 while all other exposures increased (by almost 7 per cent) (Gakidou et al, 2017).

Recent research indicates that worldwide about 20 per cent of lower back and neck pain and 25 per cent of hearing loss in adults are attributable to occupational exposures (WHO, 2018). This suggests both that occupational exposures to traditional and well-known harmful physical, chemical, and biological agents continue to occur on a large scale, and that there is still some way to go before the trend of increasing levels of occupational exposure to such risk factors is reversed globally.

According to estimates, the burden of occupational mortality and morbidity is not equally distributed across the world. About two-thirds (65 per cent) of global work-related mortality is estimated to occur in Asia, followed by Africa (11.8 per cent), Europe (11.7 per cent), America

**Figure 1: Accident fatality rates per 100,000 persons in the labour force, by region, 2014**



**Figure 2: Comparison of fatal work-related mortality by WHO regions between 2011 and 2015**

(10.9 per cent) and Oceania (0.6 per cent). This reflects the distribution of both the world's working population and hazardous work, as well as differing levels of national economic development. The rates of fatal occupational accidents per 100,000 workers also show stark regional differences (*Figure 1*), with those in Africa and Asia between 4 and 5 times higher than those in Europe (Hämäläinen et al, 2017).

There are also differences in relative contributions of various causes of work-related mortality by region (*Figure 2*), though this is also affected by differences in reporting and recording. Developed countries appear to have a higher proportion of work-related mortality from cancers (over 50 per cent) and a much smaller proportion from occupational accidents and infectious conditions (under 5 per cent). Africa has the highest relative share of work-related communicable diseases (over a third) and occupational accidents (over 20 per cent) and lowest for cancers (less than 15 per cent) (Takala et al, 2017).

These regional differences in work-related deaths and diseases reflect the multiple and

multi-faceted national, social, political, demographic and occupational differences between countries and regions globally. They also reflect different capacities to manage health and safety issues in workplaces and different capacities of national governments to effectively put in place and enforce health and safety rules. While there has been a long-term fall in occupational accidents, in global terms this has been offset by the increase in occupational injury fatalities as a result of the growing share of production to rapidly industrially progressing countries, particularly in Asia (Takala et al, 2014). Occupational accidents and work-related diseases have a substantial global impact. While underreporting of OSH data often undermines its reliability, the data here suggests that this impact varies according to where workers live and work, reflecting inequalities in their exposure to risks.

Aiming to strengthen global capacity for evidence synthesis and disease burden modelling in occupational health, the ILO and the WHO have joined efforts for estimating the global burden of work-related diseases and injury. For more detail, please refer to section 3.4.





# 100 years of safety and health at work

**This chapter of the report presents an outline of the developments concerning safety and health at work and the role played by the ILO and its constituents in relation to these over the last 100 years. It provides a chronological overview of the expansion of the field of safety and health and the improvement in the understanding of causes of work-related death, injury and disease and their prevention since the establishment of the ILO in 1919.**

## ■ 1. Why the world needed to respond to accidents and diseases at work 100 years ago

The challenge of OSH has existed for as long as people have worked or been employed in workplaces.<sup>1</sup> However, growing awareness of the widespread occurrence of injuries, diseases and deaths at work dates from the industrial revolution that took place in Europe, the United States and some European colonies in the eighteenth and nineteenth century.

Industrialization brought with it enormous upheavals in economies and in the organization of the societies. Alongside these changes were growing concerns for the safety, health and wellbeing of workers. Exposures to mineral dusts and fibres, toxic metals, biological hazards such as bacilli causing anthrax and other microbial infections, ionizing radiations, as well to the physical hazards of dangerous machinery, alongside major disasters in industries such as mining, merchant shipping, and fires and explosions in cramped overcrowded factories were well-documented by the end of the nineteenth century.

By the early decades of the twentieth century responses to these challenges had also been established. They could be seen in the form of (often hard fought) regulatory controls and their enforcement, in the growth in the organization and political mobilization of labour around OSH issues, as well as in the growth of specialist scientific, medical, hygiene and engineering knowledge on OSH, and in the development of a corps of regulatory specialists, among state administrators and social insurance organizations. Most industrialized states had a framework of regulatory controls in place, predicated on the wider legal construction of the employment relationship, and imposing duties to safeguard workers from injury or ill-health over the course of their employment, as well as provisions for financial compensation should this still occur. They were administered by states with the aid of the inspectorates established for this purpose, although such inspectorates were generally quite limited in their powers and effects (Carson, 1979).

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<sup>1</sup> Many accounts of occupational medicine begin with some historical reference to the work of Agricola (1494-1555) and Paracelsus (1493-1541) on the hazards of mining, as well as acknowledging Bernadino Ramazzini (1633-1714) on the diseases of crafts and trades in 17th century urban Italy. While others trace the origins of interest to even earlier times by pointing out references in classical Greek and Egyptian texts.



As a result, such systems were widely perceived to offer only limited protections to workers and further reforms were therefore continually sought. By the early twentieth century, prominent social reformers, lawyers, representatives of labour and enlightened industrialists, along with the networks they created, such as the International Association for Labour Legislation, had already achieved some success with international efforts to address labour issues in which safety and health were prominent — including the 1906 Berne Conventions preventing the use of White Phosphorous and night work for women (Moses, 2018).<sup>2</sup>

## MAJOR DISASTERS BEFORE 1919<sup>3</sup>



### **FACTORIES 1911**

**145 workers died in the fire at the Triangle Shirtwaist Factory in New York on March 25, 1911.**



### **MINING 1913**

**439 miners and a rescuer died in the Senghenydd colliery disaster at the Universal Colliery in Senghenydd, in South Wales (UK) on 14 October 1913.**



### **SHIPPING 1917**

**Approximately 2000 people were killed, and more than thousands were wounded when a vessel collided with a cargo ship carrying explosives at Halifax. It was considered to be the largest man-made explosion prior to the Atomic Bomb.**

While the First World War disrupted these early efforts to achieve international OSH standards, at the same time it drew attention to OSH issues. Industrial support for the war efforts of different countries led to a common increase in production of war related materials and their associated hazards. Increased exposures to toxic and explosive materials led to better understandings of the health effects and the need for improved safety measures. Finally, the end of the War provided stimulus to further international efforts to secure lasting arrangements for world peace, social justice and prosperity, through the **creation of the League of Nations and the International Labour Organization as part of the Treaty of Versailles.**

<sup>2</sup> In relation to preventing exposure to the damaging effects of white phosphorous for example, the International Convention respecting the Prohibition of the Use of White (Yellow) Phosphorus in the Manufacture of Matches — The Berne Convention 1906 was agreed by 14 countries that met in Berne in 1906. It came into force in 1912. It was one of the earliest international conventions on occupational safety and health and aimed at banning the use of white phosphorous in the match-making industry and causing matchmakers — mostly women and children — to contract the disfiguring “phossy jaw” (Moses 2018).

<sup>3</sup> Source: National Museum Wales, no date; Government of Canada, 2017; EHS Today, 2014. <https://www.ehstoday.com/safety/triangle-shirtwaist-factory-fire-march-25-1911-photo-gallery>

## ■ 2. The ILO: Founded on the concept of safe and healthy work

The ILO was founded in the aftermath of the First World War as an agency of the League of Nations, both creations of the Treaty of Versailles in 1919, to give expression to growing international concern for social, labour and economic reform. The post-War agenda for international action included awareness of the need for the protection of workers from the risks to their safety and health at work.



OSH was embedded in the rationale for the creation of the ILO (McCulloch and Rosental, 2017).

Several other provisions of the Constitution addressed broader issues that included safety and health at work — such as achieving acceptable standards on working time and ensuring the protection of vulnerable groups and children. This role was explicitly assigned to the ILO by the Treaty of Versailles.



At the very first session of the International Labour Conference (ILC), held in Washington in **1919**, the ILO adopted instruments setting OSH standards, such as **the Anthrax Prevention Recommendation, 1919 (No. 3)**; **Lead Poisoning (Women and Children) Recommendation, 1919 (No. 4)**; and **White Phosphorus Recommendation, 1919 (No. 6)**. In fact, three of the six recommendations adopted by the Conference were on OSH. The Conference also adopted conventions addressing hours of work in industry, maternity protection, night work for women, minimum age and night work for young persons. A unique feature of the ILO as an international organization was, and remains, its tripartite structure; comprising representatives of the governing administrations of its member States, in addition to equal representation of employers' and workers' organizations. Since the founding of the organization, international labour standards have reflected the outcome of negotiations between these constituents and are adopted by vote of the ILC.



In keeping with the thinking that dominated regulatory policies from the Industrial Revolution to the second half of the twentieth century, the early OSH instruments of the ILO tended to regulate single issues, such as exposures to hazardous materials or the guarding of dangerous machinery, or sectors of industrial activity, like mining, the maritime industry, construction and manufacturing. In each context, they set out prescriptive rules and focussed on the role of governments to protect workers from hazards. They generally aimed at dealing with severe OSH issues affecting a great number of workers as well as focusing on particular types of workers and on women and children.

While its approach to OSH has changed over time, the adoption and promotion of OSH-related instruments has continued to occupy a central place in the activities of the ILO. Currently, along with the major ILO Declarations, there are more than 40 instruments specifically dealing with OSH. These provide minimum standards aimed at the control and management of work-related risks and the protection of workers across a wide range of occupations and situations in which work takes place.

### **ILO international labour standards**

To date, 189 ILO conventions aim to promote opportunities for men and women to obtain decent and productive work, in conditions of freedom, security and dignity.

Eight of these are classified as fundamental conventions (on prohibition of forced labour, child labour, discrimination and the right of freedom of association and collective bargaining) which are binding upon every member country of the ILO from the fact of membership, since the Declaration on Fundamental Principles and Rights at Work in 1998.

Other conventions are binding upon member countries whose Governments have chosen to ratify them. Once ratified, conventions should be implemented into national legislation. Because there is no international labour court as such, Conventions rely for their enforcement on the decisions of domestic courts. Through its supervisory system, the ILO examines the application of standards in member States and points out areas where they could be better applied

Instruments that are developed and adopted by the ILO tripartite constituents include conventions, protocols and recommendations, in addition to codes of practice and guidelines.



From the late 1920s, efforts to create international platforms for expert dialogue on OSH became more prominent in the ILO's approach (Weindling, 1995). There were always different interests at stake from the government, employer and worker perspectives, often manifested through resistance to regulation and a questioning of OSH risks.

In 1920, the ILO established the Industrial Hygiene Section (IHS). The IHS was founded to act as a repository of information on occupational medicine and hygiene, along with its position as a focus for exchange among scientists, hygienists and occupational physicians. In 1921, the Industrial Safety Section (ISS) was also established.

This led to the decision to create the ILO Encyclopaedia which contributed greatly to the establishment of the multidisciplinary field of OSH. The first edition was published in 1930, and it has been regularly updated with new editions and contributions from thousands of experts over the years, up to the present on-line version which was first launched in 2012. It is the most widely distributed ILO publication and a fundamental reference for OSH programming -- for example, the "First Supplement to the Encyclopaedia of Hygiene, Pathology and Social Welfare" included a reference to asbestos and cancer as early as 1938.

Before the end of the 1920s, therefore, ILO member States had addressed major issues of social policy, such as sickness insurance and pensions. Those of preventive medicine for occupational diseases, however, had become technically orientated and often actions on them were not possible before substantial scientific data had been gathered and causality established. This meant that for such issues that were of international concern, it sometimes took many years between the original articulation of concern and a standard being negotiated and adopted. In the case of asbestos, for example, while the first reference in the ILO Encyclopaedia was in 1938, it was almost 50 years until the adoption of the ILO Asbestos Convention, 1986 (No. 162).



The ILO's engagement with the developments concerning the cause and prevention of silicosis in the 1930s is illustrative of the organization's work during this period. The ILO's work helped in the objective of clarifying pre-existing knowledge, defining the disease, refuting confounding hypotheses concerning its causes and creating a platform for future actions on the recognition, diagnosis and prevention of the disease.

Similar patterns were seen in relation to the advancement of prevention and control in relation to other OSH health issues during this time, with conventions and recommendations adopted on other health risks as well as on safety provisions and accident prevention. Increasingly however, the work of the ILO became more difficult as the 1930s progressed and Europe descended into more polarized and conflicting political positions, leading to the outbreak of the Second World War.

### ■ 3. Post-Second World War: An increasingly global perspective on OSH

The world in the aftermath of the Second World War was very different to the way it had been before. New political and economic allegiances and trading patterns were developing. New global institutions, such as the United Nations (UN) and the World Health Organization (WHO) were established post-War. While people in all countries continued to experience risks to their safety and health arising from their work, the new international order had significant impact on the ways in which organizations like the ILO worked to improve working conditions and OSH globally.



At the same time, scientific and professional understandings of the nature of work and its relationship to the safety, health and well-being of workers remained among the most relevant issues for developed countries. Occupational hygiene, the science of identifying, measuring and controlling potentially harmful workplace exposures, along with occupational medicine, toxicology and epidemiology continued to grow rapidly, as did disciplines associated with safety design and engineering.

In parallel with the growth of welfare provision in many developed countries, and the increased importance of social medicine, publicly funded research institutions were established. There was a corresponding growth in research output concerning issues of safety and health in many countries (Luxon, 1984).



Due to the exponential growth in the production of new substances from the mid-twentieth century onwards, there was an increased need for research into their possible harmful effects. This was also spurred by revelations concerning such effects, sometimes in relation to supposed harmless and beneficial substances already in widespread use, as for example in the case of vinyl chloride monomer (Markowitz and Rosner, 2013).

Nevertheless, there was relatively little change in the nature and orientation of regulation and control of safety and health at work, despite the burgeoning knowledge base concerning the science and engineering of prevention and control of OSH. Prescriptive measures continued to impose duties based on the established legal construction of employment relationships in most countries, either in relation to identified hazards and harmful substances or in relation to whole industries like mining or construction, where similar exposures were likely to occur. While the introduction of welfare reforms in some countries served to improve the availability of financial compensation for injury and ill-health arising out of work, little did the principles concerning entitlements change.

However, even if the fundamental approaches to OSH remained largely unchanged at national levels, the post-War reconstruction brought about some major changes at the ILO.





The **Declaration concerning the aims and purposes of the ILO (Declaration of Philadelphia)**, adopted at the 26th session of the ILC in **1944**, is often seen as heralding this change. The Declaration, which was made an integral part of the ILO's revised Constitution in **1946**, reasserted the ILO's principles that labour was not a commodity; freedom of expression and of association were essential to sustained progress; poverty anywhere constituted a danger to prosperity everywhere; argued that the war against want needed to be carried out with unrelenting vigour (in which worker and employer representatives joined government in discussion and in making democratic decisions) and placed a strong emphasis on the importance of ensuring the place of human rights in social and economic policies. Regarding the health of workers, the Declaration states that:

“

**The Conference recognizes the solemn obligation of the International Labour Organization to further among the nations of the world programmes which will achieve [...] adequate protection for the life and health of workers in all occupations.”**

In July **1948**, the first World Health Assembly of the WHO recommended that a joint expert committee be set up in conjunction with the ILO and, in **1950**, the first Joint ILO/WHO Committee on Occupational Health was convened. The overlap between the remit of the WHO in relation to occupational health and that of the ILO eventually led to the ILO abandoning the strictly medical aspects of occupational health, turning its focus towards prevention and combining actions of safety and health into one programme. In **1953**, the HIS and ISS were merged and became the Occupational Safety and Health Division.



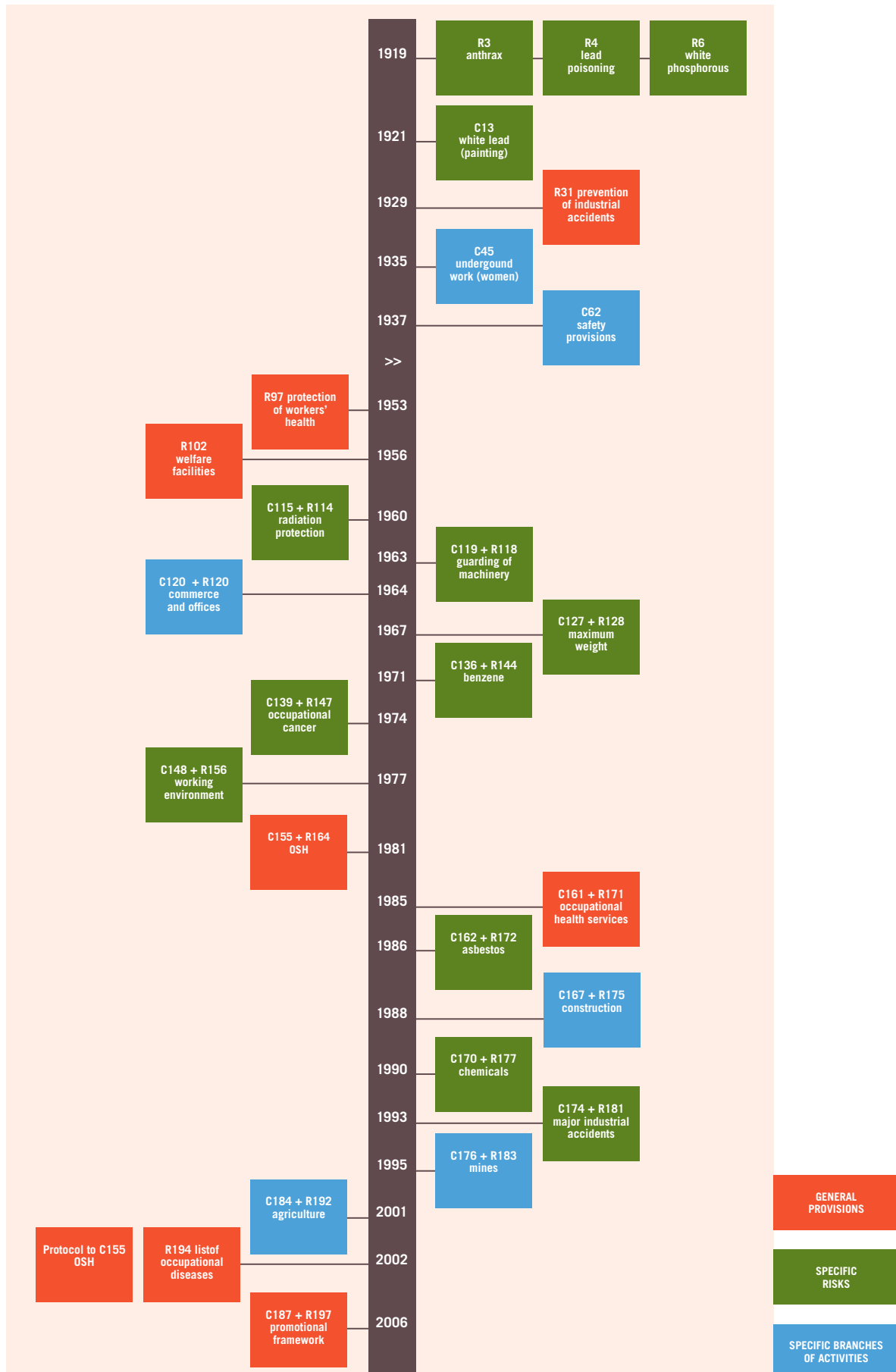
In 1959, the ILO founded the International Occupational Safety and Health Information Centre (CIS). The purpose of the CIS was to “contribute to the promotion of the health, safety and well-being of workers in all branches of economic activity by systematically collecting, scanning and abstracting all useful data, and by making the results of this analysis available in suitable form to all concerned” (Robert, 1973). The CIS became a hub of an international network of institutions involved in collecting, creating, treating and disseminating OSH information. The CIS played a major role in subsequent revisions to the ILO Encyclopaedia, with the second edition released in 1971. The CIS continued to play a major role in the management of OSH knowledge and supporting the network worldwide. Recently, with worldwide developments and improved technology, the nature of the work of CIS evolved and ceased to exist as it was before.

At the global level, the ILO also supported international study of issues relevant to its Constitution. This occurred primarily through the Geneva-based International Institute for Labour Studies, established in 1960, and through the provision of education and training activities for social partners and state administrators from member States – and especially developing countries -- through the International Training Centre established in Turin in 1965. Although these activities also addressed wider issues at various different levels, they included support for topics of safety and health.

The post-war re-development of the ILO was characterized by rapid growth of its membership. By 1970, the number of member States had doubled, and developed countries had become a minority among its members.<sup>4</sup> Consequently, the ILO introduced a programme of technical assistance, providing support for capacity building to deliver policies at national levels and in the construction of national institutions and labour inspection systems.



## ILO INTERNATIONAL LABOUR STANDARDS ON OSH



## ILO CORE INTERNATIONAL LABOUR STANDARDS ON OSH

THE ILO HAS ADOPTED MORE THAN 40 INTERNATIONAL LABOUR STANDARDS SPECIFICALLY DEALING WITH OCCUPATIONAL SAFETY AND HEALTH. THESE STANDARDS CAN BE CLASSIFIED AS THOSE:

- |   |   |
|---|---|
| <p>a) <b>RELATED TO SPECIFIC RISKS</b><br/>(such as ionizing radiation, asbestos, occupational cancer and chemicals)</p> <p>b) <b>RELATED TO SPECIFIC SECTORS OR BRANCHES OF WORK ACTIVITY</b><br/>(such as agriculture, construction and mining)</p> <p>c) <b>ENCOMPASSING GENERAL PRINCIPLES AND OUTCOMES</b><br/>(such as those relating to management of OSH, labour inspection and welfare facilities)</p> | <p>d) <b>DEALING WITH THE FUNDAMENTAL PRINCIPLES OF OCCUPATIONAL SAFETY AND HEALTH:</b></p> <ul style="list-style-type: none"><li>• Occupational Safety and Health Convention, 1981 (No. 155) and its Protocol of 2002;</li><li>• Occupational Health Services Convention, 1985 (No. 161); and</li><li>• Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187).</li></ul> |
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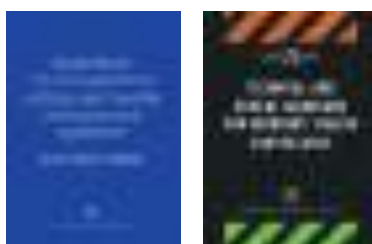
Another prominent feature of the ILO's post-war work has been the development of ILO Codes of practice and guidelines on OSH. ILO Codes, which are generally tripartite negotiated, are neither legally binding, nor replace national laws and regulations, but provide guidance as to what is required to be done to meet acceptable standards of practice, including those required by regulation. Since they were introduced in the 1950s, they have provided OSH guidance in various economic sectors (e.g. construction, opencast mines, coal mines, iron and steel industries, non-ferrous metals industries, agriculture, shipbuilding and ship repairing, forestry), on protecting workers against various hazards (e.g. radiation, lasers, visual display units, chemicals, asbestos, airborne substances), and on recording and notification of occupational accidents and work-related diseases. ILO guidelines are also the outcome documents of tripartite meetings of experts. The two key guidelines on OSH are the guidelines on OSH management systems (ILO-OSH 2001) and ethical guidelines for workers' health surveillance.<sup>5</sup>

<sup>5</sup> For viewing all ILO codes of practice on OSH see: <https://www.ilo.org/safework/info/standards-and-instruments/codes/lang--en/index.htm>

## Some ILO Codes of Practice on OSH



## ILO Guidelines on OSH



## MAJOR INDUSTRIAL ACCIDENTS AFTER 1919



### FLIXBOROUGH DISASTER 1974<sup>6</sup>

On June 1st, 1974 a cyclohexane vapour cloud explosion in Flixborough, UK took 28 workers' lives and wounded 36 other workers. It was considered to have occurred as a consequence of bad OSH management Systems.



### SEVESO 1976<sup>7</sup>

In July 1976, one of the reactors of a chemical manufacturing plant exploded on the outskirts of Meda, Italy releasing a significant amount of toxic chemicals known as dioxins. It is considered to be one of the first examples of a major industrial chemical disaster.



### BHOPAL 1984<sup>8</sup>

In 1984, at least 30 tons of methyl isocyanate (MIC) gas was released from a pesticide plant in Bhopal, Madhya Pradesh, India, affecting more than 600,000 workers and nearby inhabitants. Government figures estimate that there have been 15,000 deaths as a result of the disaster over the years. Toxic material remains and thousands of survivors and their descendants have suffered from respiratory diseases and from damage to internal organs and immune systems.



### THE PHILLIPS DISASTER 1985<sup>9</sup>

On 23 October 1989, a chemical release occurred from a chemical complex at Pasadena, Texas, United States. The incident resulted in 23 fatalities and wounded 130 to 300 workers.

6 Source: [https://blog.nationalarchives.gov.uk/wp-content/uploads/2014/05/IMG\\_4296.jpg](https://blog.nationalarchives.gov.uk/wp-content/uploads/2014/05/IMG_4296.jpg)

7 Source: Health and Safety Executive, UK: <http://www.hse.gov.uk/comah/sragtech/caseseveso76.htm>

8 Resources: <https://www.theatlantic.com/photo/2014/12/bhopal-the-worlds-worst-industrial-disaster-30-years-later/100864/> [Photo: Amnesty International]

9 Source: FEMA, USA / <https://www.usfa.fema.gov/downloads/pdf/publications/tr-035.pdf>





### CHERNOBYL 1986<sup>10</sup>

In April 1986, one of four nuclear reactors at the Chernobyl power station in Ukraine exploded. This released at least 100 times more radiation than the atom bombs dropped on Nagasaki and Hiroshima. The explosion killed 31 people immediately and thousands of people in the aftermath. The number of casualties in the region increases every year with due to long term effects including a sharp increase in thyroid cancer.



### CHILE MINING RESCUE 2010<sup>11</sup>

In 2010, 33 miners were trapped in an underground mine in northern Chile for more than two months after an accident trapped the mining exit.



### FUKUSHIMA 2011<sup>12</sup>

Following a major 9.0 magnitude earthquake and tsunami which struck north-eastern Japan on 11 March 2011, the Fukushima nuclear power plants experienced equipment failures which caused a series of explosions, fires and radiation releases. Injuries were sustained by plant workers and emergency responders.



### RANA PLAZA 2013<sup>13</sup>

On 24 April 2013, the collapse of the Rana Plaza building in Dhaka, Bangladesh, which housed five garment factories, killed at least 1,132 people and injured more than 2,500.



### THE VALE DAM DISASTER 2019<sup>14</sup>

In 2019, a tailings dam collapsed in the Brazilian town of Brumadinho. The dam break occurred at an iron ore mining complex operated by the minerals firm Vale and likely killed more than 300 people. It followed a similar incident in the same state, Minas Gerais, in 2016, which killed 19 people.

<sup>10</sup> Source: UNSCEAR / <http://www.unscear.org/unscear/en/chernobyl.html>

<sup>11</sup> Source: ILO

<sup>12</sup> Source: ILO Safe Work / [https://www.ilo.org/safework/areasofwork/radiation-protection/WCMS\\_153297/lang-en/index.htm](https://www.ilo.org/safework/areasofwork/radiation-protection/WCMS_153297/lang-en/index.htm) ]  
[Photo Credit: An aerial view of the Fukushima Daiichi Nuclear Power Station, taken on March 24, 2011. Mandatory Credit Photo by Air Photo Service]

<sup>13</sup> Source: [https://www.ilo.org/global/topics/geip/WCMS\\_614394/lang-en/index.htm](https://www.ilo.org/global/topics/geip/WCMS_614394/lang-en/index.htm)  
[Photo Credit: Anadolu Agency/Getty Images]

<sup>14</sup> Source: <https://www.theguardian.com/world/2019/feb/15/brazil-mine-collapse-vale-arrests-employees-latest>; <https://www.theguardian.com/world/2019/jan/29/brazil-dam-collapse-brumadinho-five-arrested-including-three-mining-firm-staff>

## ■ 4. Towards a culture of prevention

The concept of a “safety culture” emerged in the aftermath of the Chernobyl nuclear disaster in 1986. Several recent inquiries and reports into major incidents have considered weaknesses in safety culture as an underlying issue when trying to establish the causes of the incidents. The global political economy underwent significant change during the last quarter of the twentieth century, shifting towards market liberalism (Hughes and Haworth, 2011). At the same time, in the world of OSH policy there was a growing recognition that rapidly changing technologies, shifting patterns of work and industry, and change in the demography of the labour market required a new response. It was increasingly accepted that alternatives to the traditional single OSH issue or single economic sector approach were required to provide more holistic national policies to address increasingly divergent challenges of OSH. Inquiries at national levels concluded that such prescriptive regulatory approaches were both too narrowly focused and ill-suited to the needs of employers and workers.

Two major developments defined this period in OSH. The first was the increasing use of the notion of the work environment, to convey a more holistic approach to its understanding and improvement, exemplified, for example, by the OSH policies of Scandinavian countries from the 1960s onwards. The second was the shift of focus from prescription to more outcome-oriented and process-based approaches to OSH regulation that were perhaps first most influentially articulated in the United Kingdom (UK) Robens Report in 1972 (Robens, 1972). In combination these two approaches led to a sequence of regulatory reforms first in Northwest Europe but spreading to other advanced market economies in North America and Australasia, which overhauled previous systems and replaced them with more goal-setting and holistic standards that were more applicable to addressing OSH in the rapidly changing world of work.

The influence of the thinking behind these reforms was both reflected and advanced by the Occupational Safety and Health Convention, 1981 (No. 155) and its accompanying Recommendation (No. 164), adopted at the 67th session of the ILC. The Convention set out the basic principles for a national and enterprise level policy and strategy for the implementa-



tion of OSH preventive and protective measures. The strategy required action on the formulation, implementation and periodical review of a national OSH policy; the full participation of employers, workers, and their respective organizations, as well as other stakeholders; the definition of national institutional roles and responsibilities; a national system of recording and notification of occupational accidents and work-related diseases; the implementation of OSH arrangements at the workplace level and employers' responsibilities and rights of workers and their representatives with them; as well as requirements regarding information, education, and training.

This holistic view embracing safety and health at work was reinforced with the adoption of the Occupational Health Services Convention, 1985 (No. 161) and its accompanying Recommendation (No. 171) which were designated to ensure the implementation of OSH policy and relevant preventive and control measures. Occupational health services are entrusted with essentially preventive functions and are responsible for establishing and maintaining safe and healthy working environments which facilitate optimal physical and mental health and the adaptation of work to the capabilities of workers. The Convention and Recommendation indicates that occupational health services should be multidisciplinary and enjoy professional independence



from employers, workers, and their respective representatives, in relation to their functions. This demonstrated a recognition that the effects of the restructuring and re-organization of work would have implications for not only the risks to physical health but also to the mental health of workers. The recognition of this link was to prove prescient in coming years as the importance of psychosocial risks at work gradually increased.

A further development in the 1980s was the move to a more risk-based focus for policies on OSH. There were various influences on this development, including those arising from the analysis of major industrial disasters (such as that of Seveso in Italy in 1976, for example, which triggered worldwide attention and concern). Influence was also felt from the science of identification, analysis and control that was by then well-developed in occupational hygiene, for example in relation to hazardous exposures to chemical, physical and biological agents, as well as having wider application to the identification, assessment and control of risks in process engineering.

An increasing policy focus on more systematic approaches to risk management emerged as a result, with the identification, assessment and control of risks featuring prominently in both the safe management of major hazardous industries and in more generic guidance for workplace practice everywhere.

Systematic approaches to OSH management became central to both policy and regulatory discourse on OSH and their effects were widespread in reforms not only in Europe but in post-industrial economies all over the world. At the same time standards on OSH management systems were being developed on a voluntary basis and systems for their certification introduced. There were various links between such systems and legislative requirements and some countries, such as Australia, where adoption of certified systems was regarded as evidence of good practice.

In 2001, the ILO published *Guidelines on safety and health management systems (ILO-OSH 2001)*. These were the result of a tripartite discourse and the Guidelines pay regard to leader-

ship, its accountability and the representation of workers' interests in OSH. These developments helped to embed the systems-based approach to OSH management in global OSH policies at both national and workforce levels.

Globalization and market liberalism in the late twentieth century were reflected in the changing structure and organization of work and employment, including business re-engineering, down-sizing, outsourcing, the growth of micro, small and medium-sized enterprises and the increased importance of supply chain relations, creating new challenges for the effective protection of labour rights including OSH. Meanwhile, in many developing countries, rapid industrial growth occurred, facilitated, in part, by global outsourcing of manufacturing and industrial processes from post-industrial economies with comparatively high labour costs. Globalization of supply meant huge changes in global food and agriculture, as well as in the extraction of minerals and other natural resources, which in many cases were being produced in previously unprecedented quantities. Such production fundamentally altered both the structure of employment and services in developing countries as well as influenced wider changes in the nature of society and the economies in these countries.

Within both developed and developing countries, networks of production and services exist outside of the formal economy that provide work and forms of employment for millions of workers. Within developing and emerging economies, these often vastly outnumber those employed in the large organizations of the formal economy. Many of the workers in the informal economy are women and children, some work in micro and small enterprises while others simply operate as individuals. Their conditions of work are often beyond formal regulation. Organizing and monitoring adequate workplace safety and health arrangements for informal enterprises remains extremely challenging.

Similar patterns are seen in relation to many forms of production and services particularly in developing countries. Such situations undoubtedly contribute to the disproportional toll of injuries, diseases and deaths related to work in these countries. The challenges of implementing effective national policies on safety and health in these circumstances are sizable and augmented by the limited available state infrastructures for monitoring and seeking compliance with them.



## ■ 5. ILO and safety and health at work in the new millennium

If the early phases of ILO activity on OSH were characterized by standard setting and establishing a platform for scientific activities, followed by a second phase in which standards setting and guidance continued but were expanded to address global needs and provide technical assistance, then a third phase of its development is apparent in its responses to the challenges of globalization and the shifts in political and economic policies that accompanied it.

The response of the ILO to the need for less prescriptive approaches towards regulation and control of OSH were evident in Convention No. 155 and Recommendation No. 164, as well as the Protocol to the Convention, adopted in 2002, which addressed requirements to improve OSH governance at national levels. The Protocol to the Convention specifically aimed to strengthen recording and notification procedures for occupational accidents and work-related diseases.

As identified in the resolution of the 60th session of the ILC, in 1975, circumstances called for national and workplace level policies on OSH. This call found expression in the adoption of Convention No. 155 and the Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) and its accompanying Recommendation (No. 197). Together they require and support member States to introduce a promotional framework for OSH to achieve continuous improvement of OSH, to prevent occupational injuries, diseases and deaths, by the development, in consultation with the most representative organizations of employers and workers, of a national profile, national policy, national system and national programme. Key to Convention No. 187 is the promotion of a preventative OSH culture.

Prior to the adoption of these conventions, a renewed global approach to OSH was already in evidence at the ILO. The ILO's Global Strategy on Occupational Safety and Health was adopted during the 91st Session of the ILC in 2003 and confirms international labour standards as a central pillar for the promotion of OSH, calling for integrated action to better connect standards with other means of action to maximize impact. It outlines several key areas for action through the implementation and operation of ILO instruments, but also continued promotion, awareness raising and advocacy on OSH as well as continued technical assistance and cooperation and international collaboration to develop national programmes, protect vulnerable workers and to take a wider view of OSH, especially in relation to its social and economic benefits and its links to wider health and well-being in modern societies.



## WORLD DAY FOR SAFETY AND HEALTH AT WORK

The World Day brings tripartite strength to the International Commemoration Day for Dead and Injured Workers organized worldwide by the trade union movement since 1996 and coordinated by the International Confederation of Free Trade Unions (ICFTU). The ILO World Day focuses international attention on the magnitude of the global problem of death, disease and injuries arising out of work and how promoting and creating a safety and health culture can help to prevent this tragedy. Each year a different topic has been highlighted:

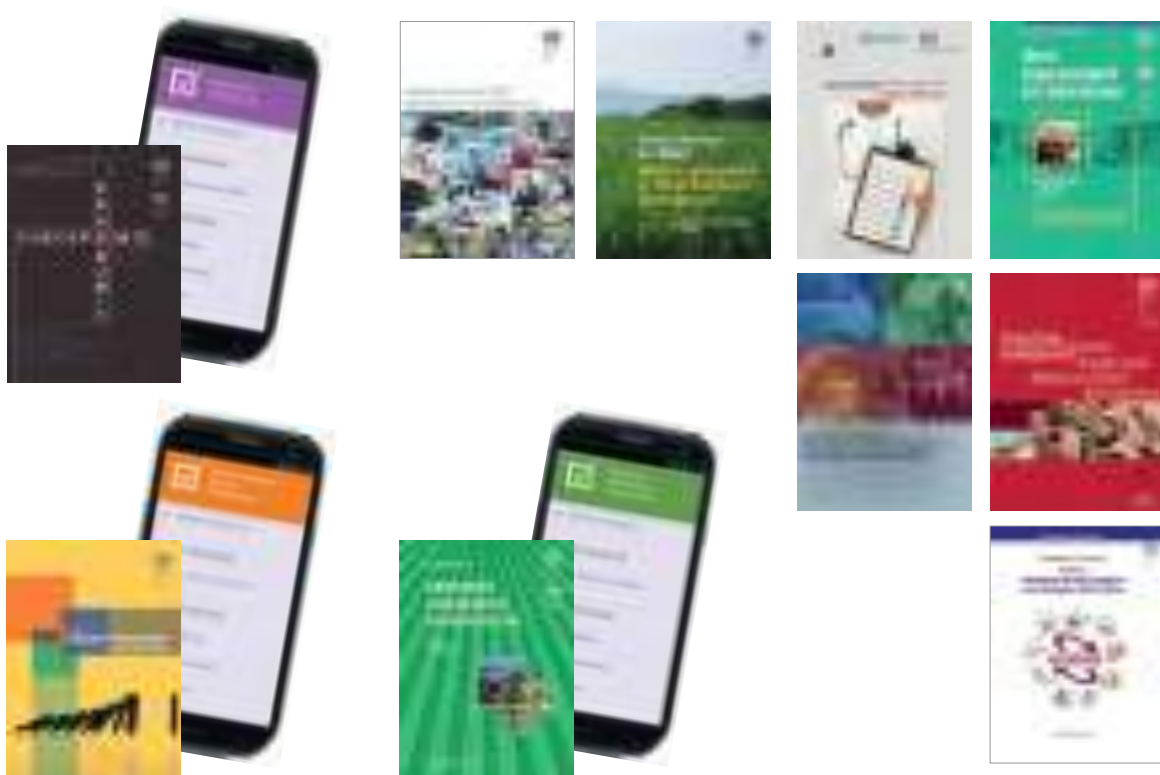


The Global Strategy called for the ILO to endorse the establishment of an annual international event or campaign aimed at raising widespread awareness of the importance of OSH and promoting the rights of workers to a safe and healthy working environment. Subsequently, the ILO has celebrated World Day for Safety and Health at Work on April 28 each year, since 2003. The World Day promotes the creation of a global preventative safety and health culture involving all stakeholders. In many parts of the world, national authorities, trade unions, employers' organizations and safety and health practitioners organize activities to celebrate this date. Each year the ILO chooses a topic to draw attention to and produces a thematic report, as well as related materials for use by participating countries for their campaigns, which may be for the day, week, month, or the entire year.

In order to promote the widespread ratification and effective implementation of OSH instruments (Convention No. 155, its 2002 Protocol and Convention No. 187), the ILO implemented

a Plan of action from 2010-2016. Through the Plan of action, the ILO secretariat promoted the conventions through a range of activities to support member States, including analysis and recommendations on draft legislation; technical cooperation to support the establishment of a culture of prevention, through tripartite consultations, advisory services or workshops; and technical assistance for the elaboration of national OSH policies. With the support of the Plan of action and other promotional activities, since 2010, Convention No. 155 has received a further 11 ratifications (67 ratifications in total), and its Protocol six further ratifications (12 in total), while Convention No. 187 has received a further 34 ratifications (46 in total) to date.

## THE ILO SUPPORTS ITS CONSTITUENTS THROUGH THE DEVELOPMENT OF NUMEROUS PUBLICATIONS AND TRAINING PACKAGES ON OSH



There was further support for labour inspection, and the operation of the Labour Inspection Convention, 1947 (No. 81) (one of the most widely ratified of all conventions) and the Labour Inspection (Agriculture) Convention, 1969 (No. 129). These instruments are two of the four ILO “governance conventions” as defined by the 2008 ILO Declaration on Social Justice for a Fair Globalization – which recognizes the importance of healthy and safe working conditions to achieving the strategic objective of the ILO Decent Work Agenda on social protection. The ongoing importance of labour inspection, including inspection of OSH, was reaffirmed by the resolution and conclusions on labour administration and labour inspection adopted by the ILC at its 100th Session in 2011. Within the ILO administration, the links between labour inspection and OSH are further highlighted by the reorganization of administrative activities in this field.<sup>15</sup>

<sup>15</sup> The ILO combines OSH and labour inspection into a single unit, entitled LABADMINOSH.

The ILO is involved with host national authorities and the International Social Security Association in the organization of the World Congress on Safety and Health at Work. This event brings together researchers, regulators, OSH practitioners and other stakeholders in OSH. It also provides the opportunity for the ILO to hold Ministerial Summits to get agreement and buy-in from a wide range of stakeholders on the adoption of new Declarations concerning OSH, such as the Seoul Declaration of 2008 and the Istanbul Declaration of 2011. The **Seoul Declaration, signed by 46 global OSH leaders**, calls for a preventative safety and health culture, which gives the right to a safe and healthy environment and which is respected at all national levels. The signatories of the Seoul Declaration commit to actively participate in securing a safe and healthy working environment through a system of defined rights, responsibilities and duties, where the principle of prevention is accorded the highest priority. The **Istanbul Declaration was signed by 33 countries**, and built on the commitments of the Seoul Declaration, recognizing a healthy and safe working environment as a fundamental human right as well as a societal responsibility, and committing these countries to building sustainable national preventative safety and health cultures. In 2017, the World Congress took place in Singapore, which concluded with calls from the ILO and partners for concerted global action to address new and emerging occupational safety and health challenges.



In 2015, the ILO Director-General proposed five flagship programmes to strengthen the impact and efficiency of the ILO's development cooperation in key work areas of the Organisation, including occupational safety and health.<sup>16</sup> As a result, the **Safety and Health for ALL Programme** mobilizes action on a global scale by deploying necessary standards, disseminating actionable information, and implementing innovative approaches that create a global, sustainable culture of worker health and safety. The programme operates mostly in developing countries and focuses on sectors with a high incidence of occupational accidents, work-related diseases and



deaths, such as construction and agriculture, and on the safety and health of workers who are most vulnerable to safety and health risks. It pays particular attention to the challenges of OSH in small and medium enterprises and also looks at opportunities to address OSH in the context of global supply chains by mobilizing relevant market players.

In 2017 and 2018, the Standards Review Mechanism (SRM) of the ILO – established in 2011 to ensure that labour standards are robust and responsive enough to protect workers in the constantly changing world of work – reviewed OSH instruments. During its third meeting, in October 2017, the SRM Tripartite Working Group (TWG) reviewed 19 OSH instruments. This review identified regulatory gaps (relating to ergonomics and biological hazards) and made recommendations, including a promotional campaign on Convention No. 155 and the Protocol to the Convention, Convention No. 161 and Convention No. 187 and specific promotion on other OSH conventions (ILO, 2017a). During its fourth meeting, in October 2018, the SRM TWG reviewed a further 9 OSH instruments, calling for: follow-up and promotion of tripartite action with member States currently bound by the Safety Provisions (Building) Convention, 1937 (No. 62); active encouragement of the ratification of OSH instruments, including but not limited to the Safety and Health in Mines Convention, 1995 (No. 176); targeted technical assistance for member States requiring the most support; and technical assistance in implementation of the Safety and Health in Construction Convention, 1988 (No. 167) and its accompanying Recommendation (No. 175) (ILO, 2018g).

While much progress has been made over the last 100 years, the challenge of creating safe and healthy work for all remains today. While many effective OSH instruments have been developed, too often they have not been ratified or effectively implemented in practice, in order to deal with persistent safety and health risks. Furthermore, new and emerging safety and health risks in an ever-changing world of work will create new challenges, as well as opportunities, for governments, employers, workers and other key stakeholders in ensuring safe and healthy working environments.



# A safe and healthy future of work: Challenges and opportunities

Patterns of deaths, injuries and diseases related to work are constantly changing across the world. These changes may be incremental or revolutionary, but have implications for the safety, health and wellbeing of workers, both positive and negative. This section provides a brief overview of some of the major transformations that are changing the world of work, and in turn, safety and health at work.

This chapter focuses on four main transformations – technology, demographics, sustainable development including climate change and changes in work organization. The report discusses the implications of these changes on the future of safety and health at work and the challenges and opportunities that may arise.

## ■ 2.1 Technology

Developments in technology affect all aspects of work, from who or what performs the work, how and where work is performed and the work that is performed, the ways in which work is organized and the terms of its performance, and the safety and health of workers. These changes and developments are accelerating; they already have a great impact on the working conditions and safety and health of workers and are expected to continue to do so in the future.

It has been suggested that the world of work is going through a ‘fourth industrial revolution’. If the three previous revolutions stemmed from the advent of steam power, electricity, and personal computers (Schwab, 2016) then the fourth is being driven by the digitalization of information. Digitalization and ICT (Information and Communications Technology), alongside related developments such as AI (Artificial Intelligence), advanced analytics, robotics, automation, autonomous vehicles, drones, smart devices, 3-D printers, novel human-machine interfaces, the Internet of Things (IoT), Big Data, cyber-physical systems, advanced sensor technologies, cloud computing, quantum computing, communications networks, e-retail, e-waste and so on, are all becoming increasingly commonplace (Stacey et al, 2016, 2017).

While it is difficult to predict their trajectory over the coming decades, there is little to suggest that the pace of these changes and developments will slow. In fact, a recent report (Stacey et al, 2016) suggests that by 2030 there may be seven trillion network devices, with all economic activity monitored in close to real time, and advanced robotics in both businesses and homes.

This section briefly outlines three interrelated key areas of development for OSH: digitalization and ICT, automation and robotics, and the use of nanotechnology.



## Digitalization and ICT

The development, use and communication of digitized information are key technological developments which are driving the ‘fourth industrial revolution’ (Garben, 2017). People are increasingly connected to digital information anywhere and at any time and this has implications for safety and health at work (Maciejewski and Dimova, 2016).

One key impact on safety and health at work is that technological developments have, in certain instances, been able to take over dirty, dangerous and demeaning jobs previously undertaken by workers (see 2.1.2 on Robotics). A related development is the growing use of AI – that is, the use of computers to try to replicate human thinking. AI is increasingly used to support workers’ safety and health in other ways, for example, in medical diagnosis. (IBM, 2016). However, in some cases the use of technology has also led to the replacement of workers, for instance, financial analysts or personal assistants (Biewald, 2015). This has implications for workers’ job security and wellbeing as job insecurity and unemployment or underemployment can have effects on a worker’s psychosocial health.

A key change for the world of work has been the ‘virtualization’ of work, leading to an increased demand for ‘flexibility’ in relation to work organization, working time arrangements and telework (Stacey et al, 2016, 2017). As well as changing how people interact at work (and, indeed at home), the development and spread of digitalization and ITC are increasingly blurring the line between work and the rest of life. There has been the increasing proliferation of practices such as telework/ICT-based mobile work and flexitime. This can provide new opportunities for people and enterprises, including in terms of health and safety. For instance, telework can reduce commuting time and associated stress and risk of occupational accidents, and can help contribute to a better work-life balance. However, it can also present OSH challenges, such as the need to manage psychosocial risks related to lone-working and the possible erosion of boundaries between work and personal life, as well as to ensure ergonomics of workstations.

Meanwhile, it is likely that workers will increasingly work outside of traditional workplaces or work remotely. While this may remove workers from hazardous workplaces, it may also introduce them to new risks. Psychosocial and organizational factors will become increasingly important as the type and pace of work, including the way it is managed changes. Other new risks can emerge from increased human-machine interfaces, including those linked to ergonomic risks (for example, from the increased use of mobile devices and sedentary work) and cognitive load (EU-OSHA, 2018b).

Smart technology and wearable smart devices can also bring opportunities for safety and health. Such devices can allow safety managers to monitor behaviour and to communicate safety and health advice and information to workers in real time. For example, smart wearables have been developed to monitor workers fatigue, fall detection and air quality. Wearable and IoT linked fatigue monitoring has been developed to detect “microsleeps” in truck drivers and heavy machinery operators (Financial Times, 2016; 2017).





Nevertheless, workers increasingly working with smart devices can lose autonomy in how they carry out their work and forego interaction with their colleagues, which can lead to stress and feelings of isolation. For example, Amazon has patented a wristband which tracks warehouse workers' locations and vibrates to 'nudge' them in the direction of their next assignment. It has been reported that many feel that their main interaction during any shift is with robots rather than colleagues (Guardian, 2018). In future, a move from wearable devices to implants is the subject of considerable research and may be part of the future of work, carrying its own OSH risks.

New opportunities also emerge from utilizing digitalization, ICT and other new technologies to spread health and safety knowledge and improve workers OSH skills and training. This can be done, for example, through health and safety apps, online training programmes, or the use of virtual and augmented reality to facilitate training. Digitalization allows for the processing of extremely large datasets (or 'big data') in order to monitor the workplace, as well as the work itself. For example, the stress or strain that a task puts on a worker can be considered, and mitigated against when planning personnel deployment (Jeske, 2016). In terms of OSH management, better data analysis can help to provide better more targeted decision making.

At the same time, however, there is a growing trend of increased monitoring of workers at the workplace through monitoring software and applications (for example, recording keystrokes and taking random screenshots), GPS trackers, and recording devices on workers' badges. While not directly related to OSH, cyber-security and data protection may affect workers wellbeing. One study has suggested that productivity apps and worker wellness programmes, two popular methods of worker surveillance, have diminished worker privacy and eroded the ability to safeguard private time and personal life (Ajunwa et al, 2016). While more research is needed on these issues, they may also lead to increased work-related stress and psychosocial health risks.

In addition to OSH opportunities at work, digitalization and ICT could help to improve workplace safety and health outcomes by improving OSH inspection. For example, drones have been used by the Occupational Safety and Health Administration is an agency of the United States Department of Labour to perform unmanned aerial inspections, often when it has been unsafe for inspectors to enter (such as an oil drilling rig fire and a building collapse). These may increase the capacity for labour inspections beyond what is currently available with too often limited human resources. (BIM Plus, 2017; Dakota Software, 2019).

The table below summarises some of the OSH challenges and opportunities that are linked to digitalization.

## DIGITALISATION AND ICT: OSH OPPORTUNITIES AND CHALLENGES<sup>17</sup>

OPPORTUNITIES	CHALLENGES
<p><b>POSSIBLE REDUCTION IN SOME PSYCHOSOCIAL RISKS FROM</b></p> <ul style="list-style-type: none"> <li>• Improved work-life balance due to telework</li> <li>• Reduction of stress associated with commuting</li> </ul> <p><b>REMOVING PEOPLE FROM HAZARDOUS ENVIRONMENTS</b></p> <ul style="list-style-type: none"> <li>• Reduced need for work-related travel</li> <li>• Increased worker control over work-life balance</li> <li>• Reduced need for real-world trial of prevention measures</li> <li>• Real-time monitoring of exposure to hazards</li> </ul> <p><b>HEALTH PROMOTION</b></p> <ul style="list-style-type: none"> <li>• Real-time monitoring of physiology and 'nudges' towards behaviours such as taking a break from computer use</li> </ul> <p><b>IMPROVED PREVENTION MEASURES</b></p> <ul style="list-style-type: none"> <li>• Increased understanding of human behaviour and its underlying mechanisms</li> <li>• Improved communication of OSH practice</li> <li>• New opportunities for OSH research, development and learning</li> <li>• Improved collection and sharing of accurate OSH records</li> </ul> <p><b>REDUCING INEQUALITY</b></p> <ul style="list-style-type: none"> <li>• Cost-effective way for developing countries to keep pace with progress in OSH</li> <li>• Improved and widened access to education and training (including for OSH itself)</li> </ul>	<p><b>POSSIBLE INCREASE IN SOME PSYCHOSOCIAL RISK FROM</b></p> <ul style="list-style-type: none"> <li>• A perceived need to be 'available' at all time, poorer work-life balance</li> <li>• Isolation (remote working and lack of social interaction)</li> <li>• Performance monitoring</li> <li>• Job insecurity</li> <li>• Cyber-bullying, -aggression and -attacks</li> <li>• Technostress and technology addiction and overload</li> </ul> <p>Can lead to:</p> <ul style="list-style-type: none"> <li>• Increased pressure to 'cut corners' (taking fewer breaks, taking risks, using performance enhancing drugs etc.)</li> </ul> <p><b>INCREASED RISK TO SECURITY AND PRIVACY FROM</b></p> <ul style="list-style-type: none"> <li>• The collection and recording of sensitive personal information</li> <li>• The loss of jobs and roles</li> </ul> <p><b>INCREASED ERGONOMIC RISK</b></p> <ul style="list-style-type: none"> <li>• From increasing use of mobile devices and sedentary work</li> <li>• Leading to increased risk of associated health problems (MSDs, visual fatigue, obesity, heart disease etc.)</li> </ul> <p><b>EXPOSURE TO NEW CHEMICAL OR BIOLOGICAL RISKS OR ELECTROMAGNETIC FIELDS</b></p> <ul style="list-style-type: none"> <li>• Electromagnetic fields</li> </ul> <p><b>INCREASED RISK OF INCIDENTS AND EXPOSURES</b></p> <ul style="list-style-type: none"> <li>• From lack of risk assessment in remote workspaces, particularly public places (cafes, transport systems etc.)</li> </ul> <p><b>OSH MANAGEMENT AND OUTCOME CHALLENGES RELATED TO</b></p> <ul style="list-style-type: none"> <li>• A more diverse (because of widened access to employment) and dispersed (because of remote working) workforce</li> </ul>

<sup>17</sup> Source: Schall et al, 2018; Yassaee and Winter, 2017; EU-OSHA, 2017a; Takala, 1998; ILO, 2018a; Reinert, 2016; Cox et al, 2014; Dewe and Kompier 2008.

## Automation and robotics

Automation and robotics are not new to the workplace. What is changing today is the pace of their development and use in an increasing range of situations. For example, Amazon's use of warehouse robots grew from 1,400 to 30,000 in a period of less than two years (Frey et al, 2016). Alongside AI, it is increasingly possible to automate more cognitive tasks previously only possible for humans. Machine learning processes make it possible for decisions to be made by AI autonomously. Robots (known as 'cobots') are also increasingly involved in working in collaboration with humans as well as in a fully autonomous capacity. Robotics provide opportunities to remove workers from hazardous situations. However, there are also concerns regarding their OSH impact in terms of human-machine interaction.



The proliferation of automation and robotics can have benefits for a worker's safety and health. Robotics and AI can alleviate human workers from repetitive and stressful tasks which can lead to musculoskeletal disorders (MSDs) or mental health risks. For instance, powered exoskeletons can be used to modify a person's habitual physical and ergonomic movements, for example, enabling them to lift heavy weights but potentially making it harder to make more simple movements (European Trade Union Institute, 2017). Exoskeletons have been used in various contexts, such as medical institutions, assembly lines, and construction. They can be useful for the prevention of MSDs and can improve worker efficiency but may carry other risks for the worker operating the equipment.

However, adoption of new robotics and automation technologies can introduce ergonomic risks through new and increased human-machine interfaces, new cyber-security risks and new or unknown psychosocial risks in terms of human interaction with AI and robotics. Recent occupational accidents and deaths have occurred as a result of robotics, such as a case in 2015 where a worker was pinned against a metal plate and killed by a robot at a Volkswagen car factory (Independent, 2015). With robots increasingly being used in agriculture, horticulture and logistics as well as manufacturing, the likelihood of increased interaction with robots and similar occupational accidents is set to increase. Risk of injury may also increase indirectly through human contact with the equipment that robots are using (Steijn et al, 2016).

As with AI and digitalization technologies, automation and robotics have generated considerable debate as to the threat of automation on employment. In general, automation is unlikely to replace most occupations entirely but instead it changes the type and number of human tasks involved in many jobs (ILO, 2018a). While automation, robotics and digitalization will create many new jobs, those that lose their jobs as a result of job replacement may be the least equipped with the skills to seize new opportunities. Workers may also need to be retrained in regard to safety and health risks associated with new work tasks. Unemployment and under-employment can have significant effects on the health of workers, particularly on psychosocial health. This highlights the increasing importance of the link between public health and occupational safety and health throughout a worker's lifecycle.

The table below outlines some of the major ways that robotics and AI can lead to safety and health opportunities and challenges.

## AUTOMATION AND ROBOTICS: OSH OPPORTUNITIES AND CHALLENGES<sup>18</sup>

### OPPORTUNITIES

- Removing people from hazardous environments;
- Robotics and exoskeletons can reduce need for workers to carry out dangerous or mundane tasks which can cause stress or MSDs;
- Improved automated prevention measures;
- Increased understanding of risk-taking behaviour.

### CHALLENGES

- Increased ergonomic risk from new forms of human-machine interaction
- Exposure to new risks:
  - Electromagnetic fields
  - Accidents as a result of loss of understanding, control and knowledge of work processes, over-confidence in robot/AI infallibility, particularly where humans and robots interact closely
- OSH management and outcome challenges related to:
  - A more diverse (because of widened access to employment) and dispersed (because of remote working) workforce
  - Job replacement and job transformation.

## Nanotechnology

The early decades of the 21st century have seen continued developments in the introduction of new materials and processes, with implications for the identification and control of risks arising from their use. One key example is in the development, production and use of nanomaterial. Nanomaterials are generally defined as those containing materials with one or more external dimension between 1 and 100 nanometres (European Commission, 2018). The unique properties of nanomaterials may result in highly desirable behaviour leading to such varying applications as more efficient consumer products and faster electronics.

Their potential continues to be explored in areas ranging from engineering and medicine to ICT. It was estimated that the global market for nanomaterial is 11 million tonnes with a market value of €20 billion, that direct employment in the nanomaterial sector is between 300,000 and 400,000 in Europe, and moreover, that products underpinned by nanotechnology would grow from a global volume of €200 billion in 2009 to €2 trillion by 2015 (European Commission, no date).



However, these materials may also pose unique health hazards that differ from those of the substance in bulk form. The increased production of nanomaterials means that workers along global supply chains will be at the front line of exposure to these materials, placing them at increased risk for potential adverse health effects.

The European Agency for Safety and Health at Work (EU-OSHA) indicates that the most telling health effects of nanomaterials have been found in the lungs, with evidence of oxidative stress, inflammation and tissue damage, fibrosis and tumour generation. In addition, nanomaterials have been found to translocate from the lungs, into the blood stream, to be taken up by secondary organs including the brain, kidney and liver, among others. Finally, some types of carbon nanotubes can lead to asbestos-like effects.<sup>19</sup>

While there is growing awareness of the potential impact on both human health and the environment, it is generally acknowledged that, so far, we lack a sufficiently detailed understanding of the relationships between the physico-chemical properties of nanomaterials, their biological toxicities, and their human and environmental health effects (Yu et al, 2015).

Nanomaterials have unique hazardous properties that are specific to their engineered states and which are not self-evident. For proper control measures to be well implemented, governments and social partners need information about these emerging workplace risks. Safety data sheets (SDS) do not always provide reliable information on nanomaterials and workers and employers should be aware of potential limitations. In addition, nanomaterials require specific control measures that can be different from those for the bulk material.

In most countries, worker involvement in health and safety issues is mandatory. Article 19 of the ILO Occupational Safety and Health Convention, 1981 (No. 155) stipulates that workers and their representatives in the undertaking should be given appropriate training in occupational safety and health. Convention No. 155 goes on to state that there should be a national policy to provide information and education and implement training for workers, including necessary further training, qualification and motivation of persons involved, in one capacity or another, in the achievement of adequate levels of safety and health. The importance of worker training on emerging workplace risks and hazards, such as the example of engineered nanomaterials, should be a key element within social dialogue on adaptive approaches for **lifelong learning** initiatives.



19 Ibid.

## ■ 2.2 Demographics

The global workforce is constantly changing, in relation to age and gender, and in terms of related issues such as migration. It is important that the implications of demographic change in relation to OSH are taken into account to help build effective policies and strategies for all workers in the present and future.

In some parts of the world youth populations are expanding, while in others, populations are ageing. These effects place pressure on labour markets and social security systems, yet also present new opportunities for inclusive, active, safe and healthy societies.



## Young workers

Some regions, such as Africa and Southern Asia, have very large young populations entering the labour force and this has implications for the workforce. Younger people (those aged under 25) are much more likely to be unemployed or underemployed. Globally, rates of youth unemployment are about three times that of older adults, at 13 per cent (compared to 4.3 per cent) (ILO, 2018d).

Critically, young workers experience significantly higher rates of occupational injury compared to older workers. According to recent European data, the incidence of non-fatal injury at work was more than 40 per cent higher among young workers age 18 to 24 than among older workers (EU-OSHA, 2007). In the United States, the risk that young workers between the ages of 15 and 24 will suffer a non-fatal occupational injury is approximately twice as high as that for workers age 25 or older (CDC, 2010).

Many different factors contribute to this increased risk for young workers. These include lower levels of physical, psychosocial and emotional maturity; education; job skills; and work experience. Young workers also lack the bargaining power of more experienced workers, which can lead them to accept hazardous working conditions and tasks, or similar conditions associated with precarious employment. They are more likely to be employed in non-standard employment arrangements and the informal economy, (ILO, 2016a) are often unaware of their OSH rights and responsibilities and may be reluctant to report OSH hazards or incidents.

Improving OSH for young workers can only be achieved by combining the efforts of governments, employers' and workers' organizations, civil society, and importantly, young people and youth organizations. Establishing shared objectives to mark national OSH progress, and taking strategic steps to improve OSH knowledge, attitudes and behaviours can drive resilience and point the way to a culture of workplace prevention.

An effective response to the challenge of improving OSH for young workers should focus on at least the five main areas highlighted during the ILO 2018 Campaign on OSH for Young Workers (ILO, 2018f):

- Improving the collection and analysis of data and information on OSH and young workers;
- Developing, updating and implementing laws, regulations, policies and guidelines to better protect the safety and health of young workers;
- Capacity building aimed at helping governments, employers, workers and their organizations address the OSH needs of young workers;
- Integrating OSH into general education and into vocational training programs, to build a safer and healthier generation of workers; and
- Strengthening advocacy, awareness and research on young workers' vulnerability to OSH hazards and risks.<sup>20</sup>

<sup>20</sup> A special thanks to Halshka Graczyk for contributing content for this section on demographics.



## Aging worker populations

Global population growth is expected to slow substantially (ILO, 2018d). Between 1980 and 2017, the world's population grew by an estimated 65 per cent, but between 2018 and 2050 growth is expected to fall to around 35 per cent. This reflects declining birth rates combined with increasing life expectancies, both of which are occurring most rapidly in developing countries.

As population growth decelerates, the overall effect will be an ageing global workforce. Many of today's workers can expect to work much later into life, while employers anticipate increasingly older workforces. The proportion of people aged 65 or more is expected to rise from about 9 per cent at present to over 11 per cent by 2030 and to nearly 16 per cent by 2050. This increases the old-age economic dependency ratio (i.e. the number of people aged 65 or more as a percentage of the total labour force), which in turn has significant consequences for the world of work, as well as for the future of OSH.

Some functional capacities, namely physical and cognitive, may start to decline in older age, as a result of natural aging processes. For example, slips, trips and falls are more common among older workers (Kemmlert and Lundholm, 2001) and the resulting occupational injuries are more likely to result in hospitalization, fatalities and fractures, particularly among older women (McNamee et al, 1997).

Health and ability among ageing worker populations may differ substantially. Many older workers may compensate for natural declines in work-related functional capacity with strategies gained through experience. As such, the focus of OSH in relation to age management should focus on adapting working conditions to working ability, and not necessarily relying on chronological age to determine capacity. Creating sustainable working conditions will increasingly require governments and social partners to develop a wider understanding of the influence of any age-related changes in work capabilities and the cumulative impact of exposures throughout the working life.

Changes in physical ability associated with ageing vary by gender, and can particularly affect the capacity of older women to work. Vertical and horizontal segregation in the labour market exposes women, and older women specifically, to different risks from those of men. Women on average live longer than men and the workplace risks encountered will affect women's health

throughout the course of their working lives. Musculoskeletal disorders, osteoarthritis and osteoporosis are diagnosed more frequently in women than in men and are age-related. To combat work-related health risks throughout a worker's life, employers should integrate both age and gender into workplace risk assessment, in order to promote healthy working conditions that match the unique challenges of ageing workers.



## INTEGRATING AGE AND GENDER INTO OSH RISK ASSESSMENTS: THE EXAMPLE OF NHS WORKERS<sup>21</sup>

The National Health Service (NHS) in the UK implemented an age and gender specific OSH risk assessment in order to address the impact of the increase of the retirement age from 65 to 68 years among their workforce. The NHS workforce is 77 per cent female, with two-thirds of nurses over the age of 40. The assessment found that if older female workers were in good health and their 'job fit' was appropriate, they were able to work as productively as their younger counterparts.

The findings of the assessment emphasized the importance of implementing sector-specific guidelines on health and well-being to ensure that a longer working life does not negatively impact health. Moreover, it highlighted that adaptive OSH risk assessment frameworks, those that evolve with the needs of the ageing population, can effectively assist organizations in addressing the cumulative impact of working for longer by minimizing risks at the source.

In addition, to better manage health among ageing worker populations, occupational physicians will need to draw upon the principles and experience of geriatric medicine towards the promotion of adaptive prevention strategies. For ageing workers to stay and thrive in work as they age, OSH systems must evolve to their needs, including investment in **lifelong learning** opportunities that favour a **human-centred approach** to decent work and well-being.

### Gender

Across the world, gender gaps in the labour market persist in both developed and developing countries. In 2018, women were still 26.0 percentage points less likely to be employed than men. Over the past 27 years, the gender employment gap has shrunk by less than 2 percentage points (ILO.2019b).

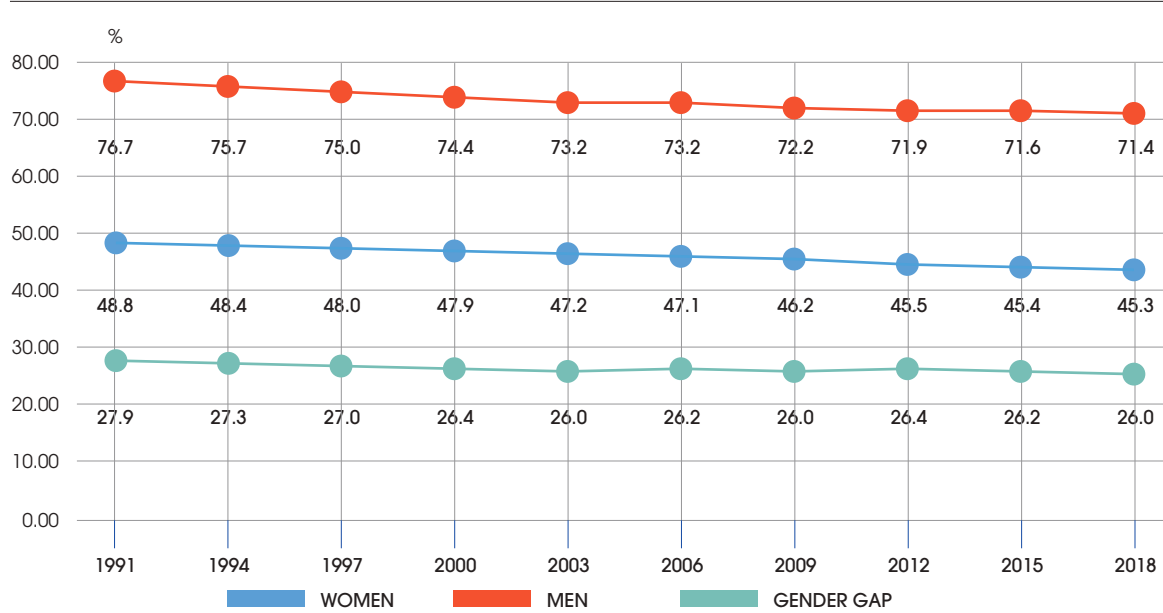
Women are less likely to find a job when they do participate; and when they do work it is more likely to be in non-standard work arrangements (ILO, 2018d; 2016a). For example, although women account for less than 40 per cent of total employment, they are involved in 57 per cent of part-time work (ILO, 2016b).

This reflects the unequal distribution between men and women of unpaid work in the home and the consequences of this for the likelihood of obtaining standard jobs (ILO, 2016a), as well as the social and political constraints both on women receiving education and entering the workforce. Similarly, women are over-represented in particular kinds of work, for instance, in the care sector, as well as in informal work and in non-standard forms of employment.

<sup>21</sup> Source: NHS Employers, 2018. Available at <https://www.nhsemployers.org/your-workforce/retain-and-improve/staff-experience/health-and-wellbeing/protecting-staff-and-preventing-ill-health/partnership-working-across-your-organisation/hswpg-resources/working-longer-in-the-nhs/job-design/risk-assessments>



**Figure 3: World employment-to-population ratios by sex, 1991–2018: age group 15 and above<sup>22</sup>**



As a consequence of concentration in particular occupations, women workers are subject to a specific pattern of injury and disease. Due to the organisational issues such as repetitive work leading to muscle strain and to fatigue, interruptions (considerably more frequent in female jobs) and lower autonomy, together with less access to training, women may face specific risks for acute and chronic work-related conditions. For example, women are increasingly affected by MSDs, and a higher risk of developing MSDs when compared to men working in the same tasks (EU-OSHA, 2013).



In home-based online platform work, women are exposed to risks that come about due to the lack of basic employment rights and risks of domestic violence, which represents a double burden for safety and health (ILO, 2017b). In addition, the growth of the platform economy has blurred the lines between home and work, adding psychosocial pressures to women who are increasingly balancing the demands of work life and home based responsibilities, such as childcare (see more on the platform economy in section 2.4). Moreover, the growing participation of women in digitalized work and information technology (IT) has led to increased online harassment, cyberbullying and trolling, resulting in psychosocial risks and work-related stress for female workers.



If future health promotion policies are to be effective for both women and men, they must take into account the evolving relationships between safety, health and well-being, and gender roles. Strategies for the improvement of women workers' safety and health should be developed within national OSH policy, particularly in sectors where women are more heavily concentrated. As more and more women join the workforce globally, specific trends of employment and exposure to emerging risks – both physical and psychosocial – must be actively monitored in order to develop effective prevention frameworks.

In addition, in a labour market where increasing trends of platform work have blurred the lines between formal and informal establishments, it is essential to consider that gender equality, and particularly how it relates to safety and health, truly begins within the home. In this regard, governments and social partners should work together to design policies that promote the sharing of care and domestic responsibilities between men and women, as well as the development and expansion of leave benefits which encourage both parents to share care responsibilities equally.

## Migrant workers

ILO (2018h) global estimates on migrant workers, covering 2013 to 2017, show migrant workers accounted for 164 million of the world's approximately 277 million international migrants. Even when employment is not the primary driver of the initial movement, it will normally feature in the migration process at some point, given that 86.5 per cent of migrants are between 20 to 64 years of age.

Migrant workers typically commence the migration process as healthy individuals. However, the complexity and diversity of circumstances throughout the various dimensions of the migration cycle may render them highly vulnerable to poor physical and mental health outcomes. While some migrant workers hold high-skilled jobs, most migrants are employed in the three “D” jobs (dirty, dangerous and demeaning) in often informal and/or unregulated sectors such as agriculture, construction or domestic work with little respect for labour and other protections. Such work is of intensive and temporary or seasonal nature, with significantly higher occupational hazards (Ujita et al., 2019).

This has implications for workers' health safety and wellbeing. Migrant workers often have poorer safety and health at work and suffer a lack of decent working conditions, frequently associated with employment in non-standard forms of employment (see Section 2.4). They are also often less eligible for social protection coverage (ILO, 2016a; ILO, 2018d; Quinlan et al., 2001; Quinlan and Bohle, 2008).

## ■ 2.3 Sustainable development and OSH<sup>23</sup>

The working environment is not a closed system isolated from the natural environment. OSH risks that give rise to a deterioration in the working environment are also among the main causes of the deterioration in the natural environment and vice versa (ILO, 1987). Air pollution from coal mining and coal burning, for example, directly impacts the health of coal miners, but also indirectly affects workers' health in other industries around them.

As such, the workplace as a source of risk generation, is a place where primary control should be exercised and where measures should be taken to coordinate environmental and labour protection (ILO, 1987). The Working Environment (Air Pollution, Noise and Vibration) Recommendation, 1977 (No. 156), makes an explicit link between the protection of the working environment and of the general environment.

In the long run, human induced climate change is a major driver transforming the world of work. The natural environment defines the world that we live and work in. As the environment changes and degrades, and efforts to ensure environmental sustainability take hold, this will inevitably have consequences for safety and health at work.



In all likelihood, the future will be characterized by increasing temperatures, changing precipitation patterns and the increased occurrence and intensity of extreme weather events (such as droughts, storms, floods). New diseases and health risks will emerge, there will be biodiversity loss, air, water and soil pollution, and natural resources will decline due to over exploitation. Climate change and environmental degradation will shape safety and health at work and the actions that are needed to protect workers, as they introduce or amplify risks in the future.

Climate change is a current and future environmental OSH hazard. Nevertheless, the impacts of climate change on OSH have received little political or public attention. This may be because increasing heat stress levels at work are mostly invisible compared to chemical exposures or air pollution. This invisible threat,

however, is just as dangerous and over certain thresholds can become lethal. Climate hazards also have the potential to interact, including in ways we cannot yet anticipate (Keifer et al, 2016; Fogarty et al, 2010; WHO, 2012; Sumner and Layde, 2009).

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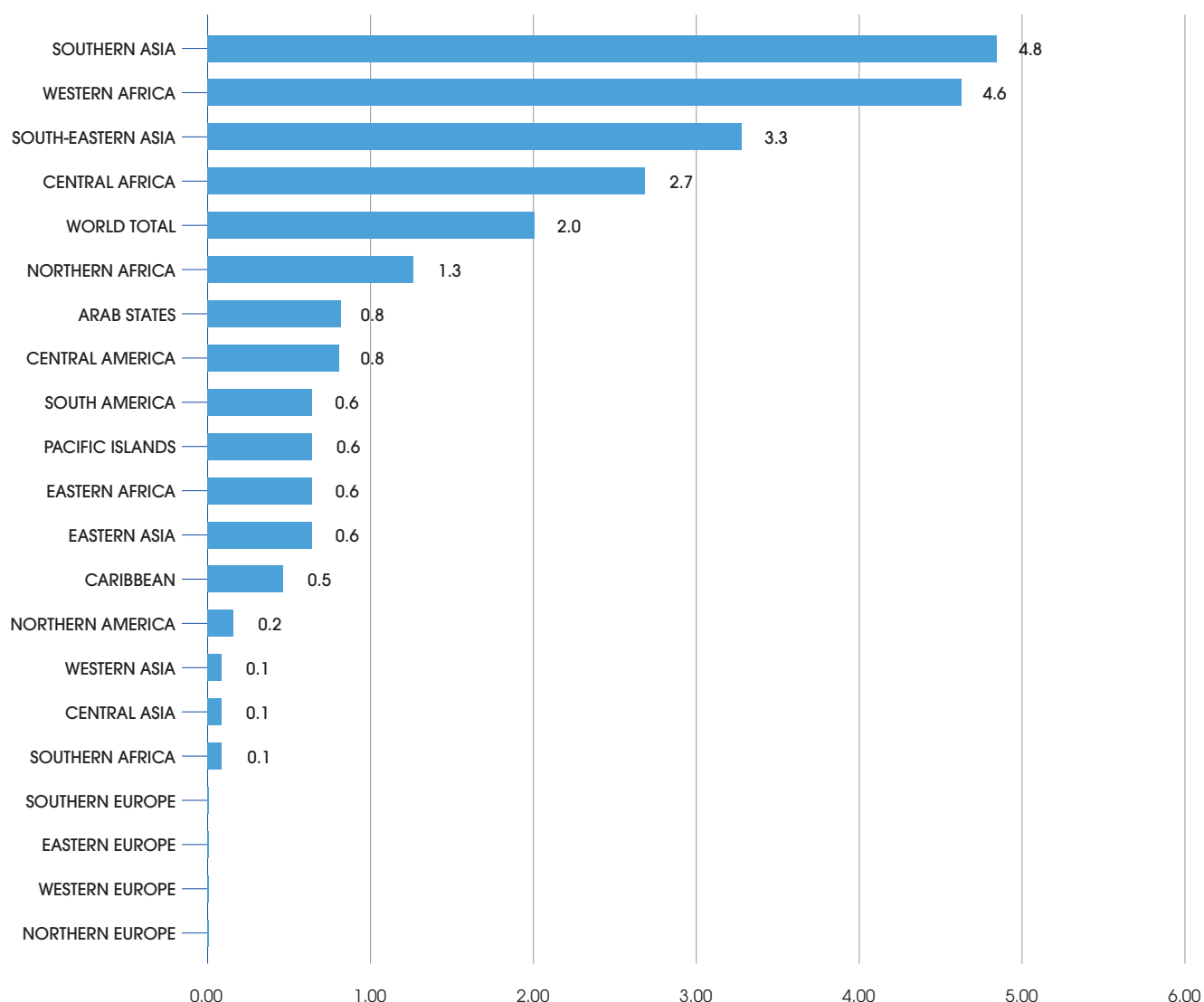
<sup>23</sup> This section has benefited from the extensive input of the ILO Green Jobs and Research Units: Marek Harsdorff and Guillermo Montt.

## Climate change, air pollution and environmental degradation

It is estimated that a projected increase in the global temperature of 1.5°C by the end of the twenty-first century will render 2 per cent of all work hours as too hot to work by 2030, representing a loss of 72 million full-time jobs (ILO, 2018c).

These effects are not being felt evenly across the world. Half of the world population live round the equator where heat levels will increase fastest. Many of those 4 billion people are among the poorest and also work outdoors, in sectors such as in agriculture. They will experience negative health and safety effects and reduced work capacity as a result (Kjellström et al., 2016). A recent report (ILO, 2018c) indicates that Southern Asia and Western Africa will be most affected (Kjellstrom, 2016). Figure 1 shows the projected working hours lost by region in 2030 under the assumption that workers slow down or stop working to protect themselves from the heat stress impact on their health.

**Figure 4: Projected working hours lost due to heat stress under a 1.5 degree scenario, 2030<sup>24</sup>**



24 Source: ILO. 2018. *World Employment and Social Outlook 2018: Greening with Jobs* (Geneva).

While indoor work will be affected, workers engaged in outdoor activities and exposed to the sun and/or engaged in physical activities are at the highest risk. This will mostly affect work related to natural resources (including, for example, agriculture, construction, fishing and forestry) but it will also depend on how workers adapt to the heat risks, the socioeconomic context and other factors such as shade and cooling (Adam-Poupart et al, 2013).

Agricultural and construction workers account for 60 per cent and 19 per cent, respectively, of working hours lost due to heat stress in 2030 (ILO, in Press).

## HIGHER TEMPERATURES AND OSH<sup>25</sup>

### HIGHER TEMPERATURES AND OSH

#### HIGHER TEMPERATURES CAN AFFECT WORK AND WORKERS, ESPECIALLY IN HOT AREAS:

**Reduction in areas where work is possible** (because of heat, rising sea levels etc.) and in people's work capacity. For example, areas in the Middle East are already too hot to work outside. The number of these areas are expanding and will accelerate;

**Increase in related health effects:** heat stroke, heat exhaustion, poorer chemical tolerance, fatigue, poorer cognitive function, increased risk of injury or safety lapses, altered responses to exposure to chemical and biological hazards, dehydration, increased burden of respiratory and cardiovascular diseases, cataract, skin and eye cancer and weakened immune function;

**Heat related OSH risks** will be exacerbated by workplaces with poor ventilation, lack of cooling systems, work involving heat-generating processes and the need to wear PPE, which workers may be less likely to (correctly) use;

**The performance of physically demanding work** notably outdoors will be severely compromised.;

**Migrant workers, informal workers and day-labourers** may be particularly affected because they are often over-represented in occupations, such as construction and agriculture which are strongly affected by rising temperatures. This may also be exacerbated by non-work-related issues, such as inadequate housing and lack of air conditioning. They often also have little or no recourse to representation or social dialogue in the workplace to claim rights at work;

**The health burden related to climate change** may be greater for workers in low- and middle- income countries in tropical areas or areas with frequent exposure to extreme weather events and high temperatures, where there are typically fewer resources available for mitigation, adaptation and risk response;

**Extreme weather events also affect workers involved in emergency, rescue and clean-up work**, who may be at (increased) risk of: exposure to chemical and infectious agents, injuries, hazards related to recovery of bodies, crowd control, assault and associated psychological and psychiatric disorders.

25 Source: Gubernot et al, 2014; Kjellstrom et al, 2009; Nilsson and Kjellstrom, 2010; McInnes et al, 2018; Malzoumi et al, 2014; Tawatsupa et al, 2013; Niera et al, 2010; Leon, 2008; Gordon, 2003; Kiefer et al, 2016; Fortune et al, 2013; UNDP, 2016; Schulte et al, 2016; Kjellstrom et al, 2013; Lundgren et al, 2013; Schulte et al, 2009.



Air pollution, notably particulate matter 2.5 such as from the burning of fossil fuels, is another serious threat to safety and health. Air pollution increases health risks for all workers and, as with heat stress, particularly affects those engaged in physical activity outside. Premature deaths from the exposure to air pollution are estimated to increase up to five times, representing up to a third of all global projected deaths by 2060, while incidents of illness worsen. According to the Organisation for Economic Co-operation and Development (OECD), an extra six million workers will miss work due to illness every day by 2060 (OECD, 2016).



Other environmental hazards that impact workers' safety and health include: climate change associated impacts such as rising sea levels, desertification and loss of productive land, polar ice melt and wild fires, UV radiation, extreme weather events, vector-borne/zoonotic diseases (which of course may result in epidemics and a global pandemic) as well as chronic diseases and health conditions<sup>26</sup> (Adam-Poupart et al, 2013; Schulz and Chun, 2009; Kiefer et al, 2016; Schulte et al, 2016).

## The green economy

Green industries, such as renewable energy production, water services, green transportation, waste management, green buildings, sustainable agriculture and forestry, recycling and the development and use of low-carbon technologies, are seeing substantial growth (Pollack, 2012). In addition, some traditional industries, such as construction, are seeing a transition toward 'green activities', such as retrofitting buildings for energy conservation (Schulte, 2010). Patterns and structure of employment, therefore, are also changing (Niera et al, 2010). Jobs and occupations will be shifting, for example, from coal mining towards renewable energy production.

While some jobs with high OSH risks, such as mining, will decline, 'green jobs' that are created are not necessarily safe and decent jobs. This is partly because OSH policy and practice can sometimes be reactive, rather than seeking to prevent new risks (ILO, 2018c). Emerging risks, often associated with new technologies, will affect workers in the new industries or occupations.

Jobs associated with green technology have predominantly contributed to employment and the economies of developed and emerging countries (such as Germany, Japan, China, Brazil and the United States) (UNEP/ILO/IOE/ITUC, 2008). OSH risks associated with new technologies will need to be addressed in those countries.

26 Potential health consequences for workers include: asthma, respiratory allergies, and airway diseases; cancer; cardiovascular disease and stroke; heat-related morbidity and mortality; chronic kidney diseases of non-traditional origin; mental health and stress-related disorders; neurological diseases and disorders; water-borne diseases; weather-related morbidity and mortality; and vector-borne, zoonotic, and other infectious diseases, such as Lyme disease, Valley Fever (coccidioidomycosis), chikungunya, malaria, and dengue; as well as exposure to heavy metals, biological, chemical, dusts and other hazards (Adam-Poupart et al 2013 Bartra et al 2007, Brooks et al 2012, Fayard 2009, Gubernot et al 2014, Kjellstrom et al 2009, Nilsson and Kjellstrom 2010, Noyes et al 2009, Portier et al 2010, Rau et al 2014, Schulte et al 2016, Smith et al 2014, Spector and Sheffield 2014, Ziska et al 2007).

Meanwhile, in emerging and developing countries, recycling activities are generally carried out by workers in the informal economy. An estimated 25 million waste pickers<sup>27</sup> work globally (ILO, 2012) and China alone employs an estimated 10 million people in the sector (UNEP et al, 2008). Waste pickers generally have little or no social, economic or legal protections, and often include women and children. They are continually exposed to hazardous substances, materials and pathogens, as well as to new, complex and hazardous waste flows, like electronic waste (ILO, 2012). A further example is the shipbreaking industry which also faces major OSH hazards which urgently need to be addressed (ILO, 2012).



27 Waste pickers collect household or commercial/industrial waste. They may collect from private waste bins or dumpsters, along streets and waterways or on dumps and landfills. Some rummage in search of necessities; others collect and sell recyclables to middlemen or businesses. Some work in recycling warehouses or recycling plants owned by their cooperatives or associations (<http://www.wiego.org/informal-economy/occupational-groups/waste-pickers>).

## GREEN TECHNOLOGIES AND OSH<sup>28</sup>

Health and safety aspects of green technologies arise in all stages of their lifecycle: from the extraction of the necessary raw materials, the manufacturing of technological devices, to their transport, installation, operation, decommissioning and disposal. They can occur across different countries and regions, involving many different groups of workers.

### WORKERS IN ‘GREEN’ INDUSTRIES MAY FACE RISKS INCLUDING, FOR EXAMPLE:

**In the wind turbine sector:** exposure to epoxy resins, styrene, solvents, harmful gases, vapours and dusts, physical hazards from moving parts, manual handling, dust and fumes from fibreglass, hardeners, aerosols and carbon fibres (Common health related problems include dermatitis, dizziness, sleepiness, liver and kidney damage, blisters, chemical burns, and reproductive effects); as well as risk of falls from heights, musculoskeletal disorders, awkward postures, physical load, electrocution, and injuries from working with rotating machinery and falling objects;

**In the solar energy industry and the later recycling of its parts** (such as photovoltaic panels): exposure to cadmium telluride and gallium arsenide;

**In the manufacture of fluorescent light bulbs:** exposure to mercury poisoning;

**In recycling:** risk of acute injury, elevated exposures to heavy metals, polybrominated diphenyl ethers, and flame retardants, increase in symptoms likely related to organic dust exposure, exposure to biological agents;

**Risks as a result of substitution for more environmentally friendly substances,** for example: the substitution of solvent-based for water-based paints has included the addition of biocides, and the substitution of hydro-chlorofluorocarbons for chlorofluorocarbons has increased the risk of exposure to carcinogens, as well as to fire hazards.

However, coal mining deaths, injuries and diseases may be reduced as fossil fuels are replaced with renewable energy, not least as mining has always been a particularly hazardous occupation and one that is often carried out in the informal sectors of developing economies by vulnerable groups of workers. Similarly, farm workers' exposure to pesticides and other agrochemicals may come down as organic farming expands.

## ILO instruments in relation to climate change, sustainable development and OSH

To address global environmental changes and their impacts on the world of work, the ILO Guidelines for a just transition towards environmentally sustainable economies and societies for all provide a comprehensive policy framework. When formulating the Guidelines, ILO tripartite constituents deliberated OSH and concluded that the current ILO normative framework does not effectively address new forms of OSH risks. The Guidelines specifically invite **“Governments, in consultation with governments and social partners, to conduct assessments of increased or new occupational safety and health risks resulting from climate change or other risks related to human health and the environment, and to identify adequate prevention and protection measures to seek to ensure occupational safety and health.”**

28 Source: ILO, 2012; Neira et al, 2010; Schulte et al, 2016; Engkvist et al, 2011; Schechter et al, 2009; Tsydenova and Bengtsson, 2011; Julander et al, 2014; Hambach et al, 2012; Hebisch and Linsel, 2012.

In taking action, it is important to ensure that the OSH risks and benefits of structural change towards sustainable economies are equally addressed in developed and developing countries. Since adverse OSH outcomes associated with climate change and environmental degradation will be more serious in workplaces and countries which do not have sufficient measures in place, it is important to address those at national and international level (Niera et al, 2010).

International labour standards play an important role in providing tools to manage the risks associated with heat stress and for ensuring decent working conditions for the workers and businesses affected.

OSH agencies around the world recognize heat stress as an OSH hazard, in accordance with Convention No. 155, and its accompanying Recommendation (No. 164). The Convention and Recommendation provide guidance for member States on how to develop and implement national OSH policies that address heat stress and other risks. Other international labour standards also offer tools for the management of heat stress risks and can facilitate adaptation efforts by governments, employers' and workers' organizations: The Hygiene (Commerce and Offices) Convention, 1964 (No. 120), the Protection of Workers' Health Recommendation, 1953 (No. 97), and the Workers' Housing Recommendation, 1961 (No. 115).

There is also a fundamental and mutual relationship between the work environment and the natural environment. For example, the Chemicals Convention, 1990 (No. 170), and the Prevention of Major Industrial Accidents Convention, 1993 (No. 174), make it clear that the objective of protecting the environment is pursued equally alongside worker protection. Standards on OSH can promote the protection of the environment through (ILO, 2018):

- Environmentally sound management of pollution and waste disposal such as regulated by the Asbestos Convention, 1986 (No. 162) and Recommendation (No. 172), the Chemicals Convention, 1990 (No. 170) and Recommendation (No. 177), and the Safety and Health in Agriculture Convention, 2001 (No. 184) and Recommendation (No. 192).
- Hazard control and accident prevention such as regulated by the Prevention of Major Industrial Accidents Convention, 1993 (No. 174).
- The protection of the environment through OSH in specific sectors such as regulated through the Safety and Health in Mines Convention, 1995 (No. 176).

## ■ 2.4 Changes in work organization<sup>29</sup>

The changing world of work has also been characterized by a shift away from permanent formal employment, particularly in developed countries where permanent employment was seen as the standard working arrangement. As discussed in this chapter, many of the changes associated with technology, demographics and climate change have in turn had impacts on work organization. This is particularly significant for ensuring safety and health at work.

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<sup>29</sup> This section has benefited from the extensive input of Janine Berg of the ILO Inclusive Labour Markets, Labour Relations and Working Conditions Branch.



Worldwide, many workers are working excessive hours, often due to changing work arrangements or low wages. Meanwhile, an increasing number of the global workforce is now involved in temporary, part-time, contract, irregular, casual, or on-call work, with zero-hours contracts, self-employment and other similar kinds of employment arrangements. These practices, sometimes referred to as ‘non-standard forms of employment’ (NSE), offer a degree of ‘flexibility’ to businesses in meeting the demands of a changing and increasingly globalized world. However, they often also result in insecurity for workers at a number of levels, ranging from job and income insecurity to a lack of employment, social and OSH protections. Furthermore, increasingly used working-time arrangements, such as telework and flexi-time affect the work life balance of workers and their safety and health outcomes at work. Meanwhile, while most of these trends apply to workers working in the formal economy, workers in the informal economy are exposed to pervasive decent work deficits including substandard OSH conditions.

### Excessive hours of work

Approximately one-third of the world’s workforce (36.1 per cent) now works excessive hours – defined as regularly working more than 48 hours per week. Excessive working hours are often necessitated by low wages, and workers facing these conditions are disproportionately represented in developing countries. While men are more likely to work excessive hours, this does not account for women spending substantially longer hours engaged in household tasks and care work. Excessive working hours are associated with chronic effects of fatigue which can lead to health problems such as cardiovascular disease and gastrointestinal disorders, as well as poorer mental health status, including higher rates of anxiety, depression and sleeping disorders.

Increased risks of non-communicable diseases are linked to excessive working hours, with a higher observed risk in women – suggesting that employers should consider how to better manage the demands of balancing work and family life of women and men workers. While other factors (such as autonomy, pressure to work overtime and low rewards) also contribute to such risk factors, in general reducing excessive working hours can contribute to improved OSH outcomes. The 2019 report of the ILO Global Commission on the future of work states that: “Limits on excessive working hours will reduce occupational accidents and associated psychosocial risks” (ILO, 2019a).





## Non-standard forms of employment<sup>30</sup>

While long and erratic hours can affect the OSH outcomes of workers, those in NSE have even higher risk of having their safety and health adversely affected at work. At least four categories of risks are associated with these forms of work organization: injury-related risks and accidents, psychosocial and harassment risks, exposure to poorer working conditions and hazards, and fatigue issues.

Injury rates amongst temporary and temporary agency workers can be considerably higher than those of other workers. This occurs primarily because workers are hired to do hazardous tasks that permanent workers do not want to do, and/or are young and inexperienced, or with limited experience, bargaining power and representation on safety and health committees. Non-standard workers usually have less access to training, which is vital to prevent accidents. Injury rates are almost twice as high for temporary and temporary agency workers in New Zealand (Schweder, 2009.) and substantially higher in Italy (Fabiano et al., 2008; Bena et al., 2011) and India (Maheshrengaraj and Vinodkumar, 2014). In Asia, typical examples include migrant workers employed on contracts in the construction sector in Malaysia (Serrano et al., 2014) and dispatch workers employed in manufacturing in Viet Nam (Pupos, 2014). There is evidence of greater accident rates among agency workers in France (13.8 per cent compared to 8.5 per cent), Spain (2.5 times higher than for permanent employees) and Belgium (twice as high per 1,000 workers) (Vega-Ruiz, 2014). Subcontracting -- particularly multi-level subcontracting -- is associated with higher risk of accidents as workers move between worksites and suffer from informal working arrangements. Sub-contracted truck drivers, for instance, have been found to face a range of safety and health risks (including excessive hours, drug use, speeding and maintenance) in many countries.

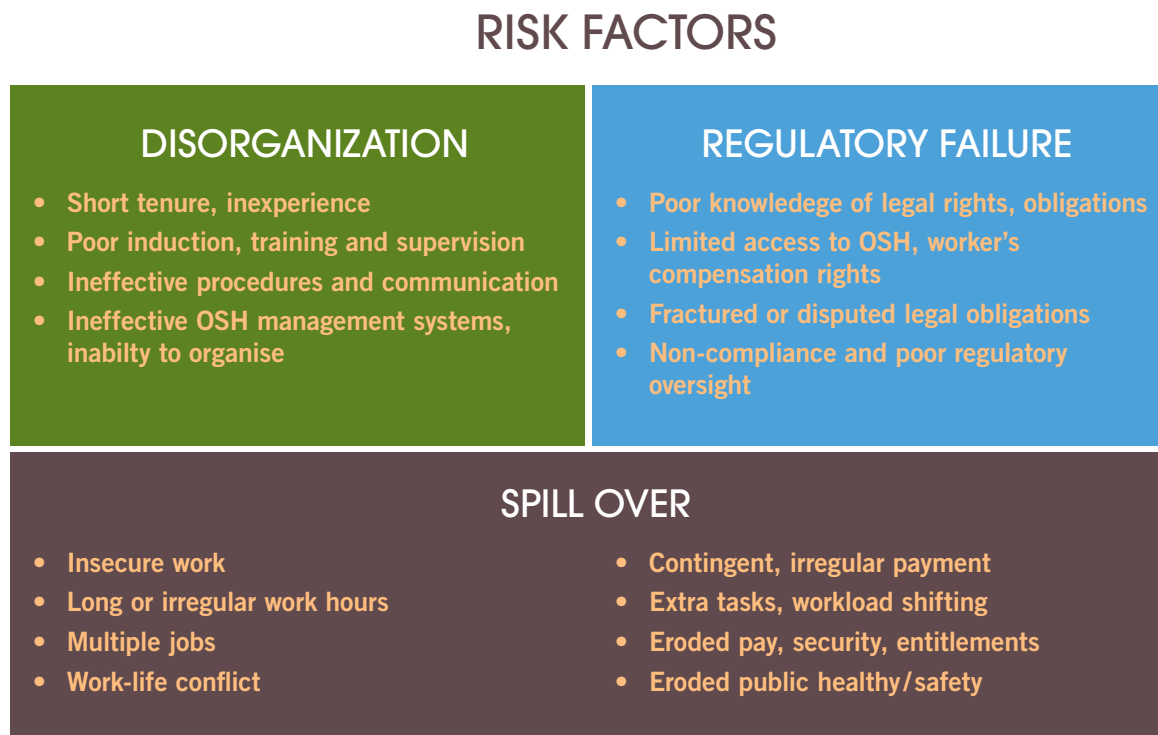
In addition to injury and accident-related risks, NSE are associated with psychosocial risks to workers. Having an involuntarily temporary or part-time job may lead to stress for workers arising from perceptions of job-insecurity. Workers exposed to job-insecurity are more likely to report minor psychiatric symptoms and have higher self-reported morbidity than those in secure jobs. Temporary workers may also be more susceptible to violence and harassment, including sexual harassment, with economic insecurities exposing workers to higher risk of supervisory abuse. In Japan, for instance, temporary workers were found to be at a higher risk of being bullied, while in Australia sexual harassment of part-time workers was found to be significantly higher (Tsuno et al., 2015, Lamontagne et al., 2009).

Furthermore, workers in NSE may lack decent working conditions, leading to increased exposure to various hazards. The evidence on this issue is mixed. As previously discussed, employers often hire temporary or temporary agency workers for more hazardous work, however, part-time workers may be exposed to hazards such as noise or poor ergonomic conditions for shorter periods. In agriculture, workers who are exposed to herbicides for shorter periods, for example, are at lower risk. However, if they have to cope with poorer washing facilities or accommodation that exposes them to risk factors, this may counteract any effect of shorter working hours (Kachaiyaphum et al., 2010).

Finally, NSE are associated with higher levels of fatigue. While flexible working hours can help women and men workers balance work and family commitments. Evidence suggests that perceived benefits vary significantly between occupations and with regards to the ability of workers to influence their hours of work (Beham et al., 2012).

<sup>30</sup> This sub-section is based on Quinlan, 2016; as adapted in ILO, 2016a.

Figure 5: OSH risk factors in non-standard employment arrangements<sup>31</sup>



<sup>31</sup> Source: ILO, 2016a; Adapted from Quinlan et al., 2013.

## Working time arrangements

With the emergence of new technology, working-time arrangements such as telework, ICT-mobile work (ICTM) and flexitime have become more common. While employers often require a more flexible workforce, changing lifestyles and family structures have meant many workers also demand more flexible working arrangements. Flexible working arrangements can help workers to find a better work-life balance, particularly for women and men with families, and help workers to remain economically active who may not be able to do so otherwise, including older workers or workers with disabilities. However, they often result in the erosion between the borders of work, leisure and other activities, can intensify work and time-related stress and lead to psychosocial health risks.

Telework work often leads to higher levels of intensity of work and the increased likelihood of work-family conflict. This in turn can have well-being effects on workers and increase their stress levels. In fact, 41 per cent of workers doing high mobile ICTM report high levels of stress, compared to 25 per cent working from the employer's premises. This is particularly significant where workers are obliged to work from home beyond their normal working hours. Telework and ICTM are also associated with sleeping disorders, which are in turn related to stress levels (Eurofound and ILO, 2017).

A significant challenge relating to applying safety and health at work to these working time arrangements is the difficulty of supervising work that takes place outside of the employer's premises. While telework and ICTM can play a part in inclusive labour markets for older workers, women with children and people with disabilities, training and awareness initiatives are required for workers employed under such arrangements and governmental initiatives, as well as national or sectoral collective agreements can help to provide a framework for a telework and ICTM strategy (Eurofound and ILO, 2017).

## The informal economy

Most of the developments listed in this section relate to the formal economy. Crucially, however, more than 60 per cent of the world's employed population work in the informal economy (ILO, 2016a). Workers in types of 'non-standard forms of employment' may be particularly exposed to the risk of informality. Numbers of workers employed in the informal economy vary by region. For example, informal employment makes up 82 per cent of non-agricultural employment in South Asia, 66 per cent in Sub-Saharan Africa, 65 per cent in East and Southeast Asia, 51 per cent in Latin America and 45 per cent in the Middle East and North Africa, but just 10 per cent in Eastern Europe and Central Asia (Vanek et al, 2014).

Workers in the informal economy may not have a regular income and are likely to have little or no legal or social protections, no access to union or other forms of representation, collective bargaining or social dialogue, and their work often falls outside the remit of labour inspectorates, making them effectively invisible from the point of view of OSH regulation and control. Improving safety and health and working conditions of employers in the informal economy entails a transitional strategy to formalize workers in the informal economy. Nevertheless, measures to improve safety and health at work for workers in the informal economy, such as measures to improve working conditions and increase productivity of micro and small-sized enterprises in addition to capacity building programmes can help immediately improve outcomes for informal workers (ILO, 2014).



## The example of digital labour platforms

One major development of the past decade in the world of work has been the emergence of digital labour platforms. Digital labour platforms include web-based platforms, where work is outsourced to a geographically dispersed crowd of workers (known as “crowdwork”) and location-based applications (or “apps”) where work is targeted at a specific geographical area (ILO, 2018e). Digital labour platforms are now found in virtually all sectors, and operate regionally, nationally and internationally. They also include a very wide range of working arrangements and relationships.

When seen from the perspective of the control of work and the security of employment, much of what is promoted as ‘new’ in terms of the impact of this technology, often represents more casualized (and less secure) employment commonplace prior to protections introduced by regulation and the influence of organized labour in industrialized countries from the late nineteenth century onwards. Work on digital labour platforms is often similar to work arrangements as far back as the 1800s which were based around piecework and organised through guilds (Garben, 2017; Hong, 2015; Risak and Warter, 2015).

Work on digital labour platforms can include (versions of) casual work, temporary agency work, dependent or quasi-self-employment, informal work, piecework, home-work and crowd-work. Platform work can comprise work that is carried out digitally or manually, in-house or outsourced, high-skilled or low-skilled, on-site or off-site, large- or small-scale, permanent or temporary (Garben 2017).

Currently, the share of total employment through digital labour platforms is relatively small. Estimates range from 0.5 per cent of the labour force in the United States (Farrell and Greig, 2016) to 5 per cent in Europe (European Parliament, 2017). However, it is almost certain to expand, not least as a number of governments in developing countries, such as Malaysia and Nigeria, are adopting strategies to encourage workers into this kind of digital labour (Graham et al, 2017).

Work on digital labour platforms is often portrayed as being typically carried out as a secondary job, providing additional income to those involved, rather than being their primary income source. It can provide important new opportunities for people and businesses. However, it has been associated with an over-emphasis on ‘quasi-continuing availability’. In addition, its portrayal as a supplement to income from ‘proper’ work means that it is sometimes seen as somehow less ‘real’, and consequently less ‘deserving’ of traditional labour protections (Garben, 2017; Prassl and Risak, 2016; Berg, 2016). This has important implications for workers’ OSH, in terms of the OSH protections extended to them and the psychosocial implications of the impact on work-life balance and worker self-esteem.

Digital platform work may be able to generate safety and health opportunities, such as increasing a worker’s control over the hours they work and their work-life balance and moving work normally carried out in the informal economy into the formal sector, where there may be enhanced safety and health regulation and protection (Garben, 2017; ILO, 2018b).

However, it can also lead to a number of OSH challenges and suffer from a lack of safety and health protection. Platform workers may experience worse OSH management of the workplace, including poor risk assessment. Furthermore,



workers often have little or no access to traditional contractual benefits (holiday and sick pay, OSH information, training, services and support) or to employer-provided workplaces, equipment and personal protective equipment (PPE) (with workers' own homes and supplies unlikely to meet ergonomic, environmental and OSH standards). In fact, in many cases workers are responsible for their own OSH and for other factors such as insurance (Garben, 2017; EU-OSHA, 2015). It may be difficult to regulate OSH in platforms that are operating globally, highlighting the increased need for governance at the international level.



## PLATFORM WORK: OSH OPPORTUNITIES AND CHALLENGES<sup>32</sup>

### OPPORTUNITIES

- Removing people from hazardous environments.
- Greater control over work-life balance.
- Shift of work previously carried out in the informal economy into the formal sector.

### CHALLENGES

- Reduced security, decreased regulatory visibility and increased risks.
- Atypical employment and working arrangements (which can include clauses stating that there is no employment relationship between the platform and the user, that workers are independent contractors, and that the platform is an intermediary and so not liable).
- Platform operators may challenge the applicability of OSH and employment regulations.
- Workers often have little or no access to traditional contractual benefits (holiday and sick pay, OSH information, training, services and support) or to employer-provided workplaces, equipment and PPE (with workers' own homes and supplies unlikely to meet ergonomic, environmental and OSH standards).
- Workplace OSH management may be poorer – for example, risk assessment is often infrequent or non-existent.
- Lack of task clarity and specificity is common.
- Appropriate certification, knowledge or understanding of the relevant regulations is less common.
- Workers are in effect responsible for OSH and for other factors, like insurance.



# Responding to the safety and health challenges and opportunities of the future of work

While the changes shaping the future of work are creating new challenges for prevention, it is worth noting that these changes also create new opportunities to improve prevention efforts. This Chapter aims to reflect on how the field of occupational safety and health is effectively rising to the challenge. This can only happen by bringing together all key stakeholders at global and national levels. Governments, employers and workers form the foundation for building a safe and healthy future of work.



## ■ 3.1 Anticipation of new OSH risks

With new technologies, shifting demographics, climate change and different patterns of employment and work organization shaping the world of work, it has and will become more important than ever to anticipate new and emerging work-related safety and health risks. Anticipating risks is a crucial first step to effectively managing them and to building a preventative OSH culture in an ever-changing world.



In recent years, foresight processes have emerged, particularly in Europe, which aim to identify and prioritize research and innovation to deal with the type of changes identified in this report. These include practices such as forecasting, technology assessments and future studies, which enable the identification of potential work-related safety and health risks and the development of effective preventative actions. Anticipating future risks has clear benefits for dealing with emerging risks over traditional methods based on accidents and disease statistics and epidemiological data, approaches that were seen in action over the development of OSH over the last 100 years, detailed in **Chapter 1** of this report.

In relation to new technology, further research is needed on the effects of new technology, such as the rise of digitalization, new applications of ICT, AI, robotics and nanomaterials. Psychosocial risks require additional attention, particularly in terms of determining situations and employment practices that effect work-related stress and mental health outcomes – biomarkers, for instance, may be used to detect and diagnose stress levels. With regards to psychosocial risks, further consideration and research is required on issues such as:

- How to integrate psychosocial risks in risk assessments as part of OSH management systems in order to develop targeted prevention and hazard management strategies, interventions and evaluations;
- How to develop a psychosocial safety climate and better manage mental health at the workplace;
- Understanding the dynamics of antecedents of stress (unhealthy work stressors) and the antecedents of well-being (including demand-resource models and issues related to the individual), organisation and the environment;
- The correlation between psychosocial risks at work and their effect on the physical health of workers including Cardiovascular Diseases and Musculoskeletal Diseases, hypertension, gastrointestinal disorders and mental health disorders (burnout/ depression) etc.; and
- The correlation of excessive working hours and sedentary work with physical health effects on workers.

New trends in work organization, where workers increasingly work autonomously or away from their employer's premises require a rethink of current OSH management, laws, policies and programmes. In these cases, including the example of platform work, there may or may not be an established employment relationship or the worker may be self-employed.

Issues including, but not limited to isolation, socialization, personal protective equipment, access to information, representation, organization of work, liabilities for illness or accidents arising out of work are key issues that must be dealt with to anticipate and shape a preventative safety and health culture in the future. This vision for the future can integrate new technology at the service of OSH, such as safety applications, analysis of big data and AI. The risks of integrating these new technologies into the workplace should be accounted for. Meanwhile,

as discussed in [section 3.4](#) bridging the gap between occupational health, public health and environmental health and general well-being is essential for anticipating and preventing new and emerging risks.

Well-being is a further concept that relates to all aspects of working life. This includes the safety and health conditions of the working environment, but also how workers feel about their working environment, the climate of work and work organization. Worker wellbeing is an important determinant of the long-term effectiveness of an organization. Further research and attention is needed in order to address questions in regard to the future of worker well-being including:

- How can the implications of advancing technology and new occupations on the health and well-being of workers be addressed?
- What can be done to ensure worker wellbeing with varying employment arrangements and conditions?
- How can the burden of shift work, long hours of work, and sleep deficiency be decreased?
- How can stakeholders promote sustainable work and non-work interface?
- How can opportunities for positive physical and psychological work environments and a supportive organisational culture/climate be fostered?
- What is the role of health promotion in the present and future world of work?
- Can healthier work design, health promotion and better organisational practices improve the safety, health and well-being of workers?
- What is the relation between a safety climate, job satisfaction and turnover?
- How does violence, bullying and harassment at work affect well-being at work?
- What is the influence of macro-level factors and social inequality on worker health and well-being?
- Is human well-being a concern for ‘white-collar’ workers only? How do emerging and developing economies perceive psychosocial factors at work and are psychosocial risks limited to certain occupations or are they a wide spread phenomenon?



While the anticipation of new and emerging risks is becoming increasingly important in a rapidly changing world of work, this should not draw focus away from the persistence of traditional risks across the world, which vary in terms of geography and economic sector.

## ■ 3.2 Multidisciplinary in managing OSH

Multidisciplinary in OSH links to the future of OSH professionals and the question of what it will mean to be an OSH professional in the future. The nature and role of OSH professions has altered in many countries, in keeping with changes in the structure of the economy. For example, occupational hygienists have become less of a professional presence and less influential in those economies in which manufacturing, heavy industry and mining have declined, while more general OSH practitioners may have grown in numbers and influence. The position of OSH professionals is not static but rather is subject to change.

Boundaries between work, domestic life and public roles in communities in which people live as well as work, are predicted to become increasingly blurred by the changes that continue to take place in the structure, organization and control of work. These matters are likely to require a combination of disciplines to address the various concerns arising from these changes.

A broader focus on OSH requires the consideration and application of new skills sets in the field. These include psychosocial and economic disciplines. Protecting the workforce of today and of the future necessitates a holistic view of the hazards that workers experience and the range of adverse effects that occur as a result. For instance, underemployment appears to have health effects more like those of unemployment rather than those associated with adequate employment.

Therefore an interdisciplinary approach to OSH should aim to bring together such disciplines as; the law (public policy and employment law); work design (engineering, ergonomic, software, and automation); tools (technology, health tech, and sensors); the environment; physical and social impacts (public health, nutrition, physical activity, and demographics); human nature (psychology sociology and economics); medicine and neuroscience; and work organization, in addition to design and human resources.

### ■ 3.3 Building competence on OSH

For most of the past 100 years of OSH, detailed in **Chapter 1** of this report, OSH was regarded as something experienced by workers, their managers and employers when they enter the world of work and learn how best to look after themselves and others in this context. In this respect, learning about safety and health at work has been largely an ‘add-on’ to learning that becomes relevant only at the workplace and something quite separate from general education.

There is a growing need to mainstream OSH into the core of general education for everyone before they enter the world of work and continuing throughout their working lives. There are some signs of the growing awareness of this need among OSH policy-makers but there is some way to go before it becomes a reality for society at large.

Integrating OSH into general education and into vocational training programs can help build safer and healthier future generations of workers. Training and educating workers on OSH at every level is a highly effective method of building OSH awareness, knowledge and skills among the world’s workers and employers, particularly young workers.

In the 2019 report, *Work for a brighter future*, the ILO’s Global Commission on the Future of Work proposes “a universal entitlement to **lifelong learning** that enables people to acquire skills and to reskill and upskill” (ILO, 2019a). This forms part of a strategy to invest in people’s capabilities, alongside supporting people through transitions, a transformative agenda for gender equality and strengthening social protection. **Lifelong learning** spans formal and informal learning, through childhood and basic education to all adult learning. Including OSH education and training in **lifelong learning** can help workers and employers adapt to new, emerging, and persistent safety and health risks and improve OSH outcomes at work.



## ■ 3.4 Widening the horizon: The link to public health

OSH does not end at work. The effects and outcomes of OSH have a clear spill over on people's health and wellbeing in general, and on that of society as a whole. If work is recognized as a social determinant of health, then there is a need for greater attention to the connections between OSH and public health, and on possible new roles for occupational health, including, for example, in health promotion, prevention and management of emerging psychosocial risks, mental health disorders and non-communicable diseases. The link between OSH and public health has implications for the interconnected infrastructures that govern health care, environmental health, and social welfare and social protection, as well as for the nature and approach of civil society institutions in their engagement with OSH.

The link between public health and OSH can be recognized in the need to promote healthy work environments (including work practices) that support health and prevent diseases through organizational improvements. Issues such as nutrition (access to affordable and healthy food during working hours), increased physical activity, good sleep, addressing psychosocial hazards, preventing substance abuse and other addictions can all be positively influenced by our working environment. There is therefore a strong bridge among various mechanisms (occupational health services and public/private health services) to support the health of workers.

There is increased recognition of the links between safety and health at work and the cause and prevention of psychosocial disorders and non-communicable diseases – such as hypertension, cardiovascular disease, gastrointestinal disorders, diabetes and other leading causes of mortality. This may call for expanded protection through public health approaches and services and more research on the combination of procedures governing occupational and environmental health, considering, for example, aspirations for a better quality of life that are closely joined with other activities relating to the protection of the human environment.

For most workers, the norm is no longer to work for a single employer. Instead, a worker's lifecycle encompasses many employers and potentially several jobs and careers of various forms. The lifecycle of a worker also spans from education, to training, to work, to managing various responsibilities, to social protection and to retirement. **Lifelong learning** is increasingly part of the worker lifecycle. Therefore, the safety and health of an individual as a human being as well as a worker, is crucial to public health and OSH, as it is a constant factor in all forms of work.



The health of a worker and the workforce is affected not only by occupational risk factors but also personal risk factors, social and economic risk factors. These factors can have an impact on health outcomes and potentially influence one another. This work life approach links to the **“human-centred agenda for the future of work”**, as called for by the ILO’s Global Commission on the Future of Work, which requires investment in people’s capabilities, enabling them to acquire and update skills and supporting them through the transformations they undergo in their life course (ILO, 2019a).

Safety and health at work needs to address not only hazards in a single job but also along the whole work life continuum. This means addressing job insecurity (such as those associated with non-standard forms of work) and attendant stresses and anxieties, as well as the times between jobs, as unemployment and underemployment which can also cause significant health problems (these are conditions also known as “occupational health hazards.”)

The shifting boundaries between work and domestic life, as identified in [Chapter 2](#) of this report, also have important implications for protections for workers that may be offered by public health approaches and services. Where work occurs beyond the traditional confines of the workplace, public health may face additional challenges in protecting the health and wellbeing of workers.

The employment relationship is increasingly fragmented -- often in terms of limited-term contractual agreements or other non-standard forms of employment -- and workers face many different working conditions and working arrangements. Many workers are underemployed or unemployed and these conditions can also have adverse health effects, which may increase the burden on public health.

While the importance of safety and health at work cannot be understated, many of the improvements made in relation to OSH over the past 100 years have gone hand-in-hand with social and economic development more generally. Strategies to achieve social and economic development go far beyond those related to OSH; nevertheless, OSH should to be properly integrated into wider development approaches. This in turn highlights the link between OSH, decent work, public and environmental health and sustainable development, as per the UN’s 2030 Agenda for Sustainable Development –in particular, the link between **Sustainable Development Goal (SDG) 3 on “good health and wellbeing”** and **SDG 8 on “decent work and economic growth”**.

Aiming to strengthen global capacity for evidence synthesis and disease burden modelling in occupational health, the ILO and the WHO have joined efforts for estimating the global burden of work-related disease and injury. Building on existing robust methodologies to estimate the occupational burden of disease for 39 pairs of occupational risk factors and health outcomes, the new methodology will allow for estimating the burden of 13 additional occupational risk factor-outcome pairs including:

- occupational exposure to solar ultraviolet radiation and skin cancers and cataract;
- occupational noise and cardiovascular disease, and
- long working hours and Ischaemic heart disease, stroke, depression and alcohol use disorders.

These estimates will also serve as useful indicators across SDGs 3 and 8.



## ■ 3.5 International labour standards and other instruments on OSH

In an ever-changing world of work, the ILO's OSH instruments are still extremely valid and relevant. Not only are conventions and recommendations reviewed to ensure they are robust and responsive to changing demands, they are drafted in such a way as to be resilient to the changing OSH challenges.

As identified in **Chapter 1**, the latest OSH instruments emphasize the importance of developing a national preventative safety and health culture in which the right to a safe and healthy working environment is respected at all levels. The active participation of governments, employers and workers is key to securing a safe and healthy working environment built around the principle of prevention. The Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) and its Recommendation (No. 197) provide for a framework for OSH, including a national profile, a national policy, a national system and a national programme on OSH. This occurs in consultation with the most representative organizations of employers and workers.





While the **Occupational Safety and Health Convention, 1981 (No. 155)**, was adopted almost 40 years ago, it contains a number of provisions that make it ever-relevant. For example, the Convention:

- Calls for member States to continuously “undertake or promote studies and research to identify hazards” and employers to “keep abreast of scientific and technical knowledge”, linking to the need to continuously anticipate, research and question the hazards and control measures that are in place;
- Provides for “recourse to specialists” to advise on particular OSH problems or supervise the application of measures to meet them, relevant to the emergence of new production processes that we don’t yet fully understand the risks of, and the need to consult various actors from different disciplines;
- Provides for arrangements regarding OSH and the working environment “adapted to the size of the undertaking and the nature of the activities”, allowing to adapt these processes with the changing world of work;
- Calls for “ensuring that work organization, particularly with respect to hours of work” and rest breaks does not adversely affect OSH, ensuring that the Convention is relevant to the work organization issues discussed in this report; and
- States that employers should undertake all reasonably practicable measure with a view to eliminating not only excessive “physical fatigue” but also “mental fatigue” -- one of the key risks on the rise today.

International labour standards (both conventions and recommendations) and the other instruments on occupational safety and health (codes of practice and guidelines) continue to play a key role in ensuring and promoting a safe and healthy working environment. The role of international labour standards was emphasized in the **ILO’s 2003 Global strategy on occupational safety and health**, which reaffirmed international labour standards as a central pillar for the promotion of OSH and called for integrated action to better link standards and other means of OSH action to increase their impact. This approach remains relevant and applicable in the changing world of work today.

## National OSH legislation and management

National OSH legislation is a central pillar of national OSH systems and will continue to play a key role in the future. This is because all OSH systems need to be sustained on a solid legislative basis.

Legislation is not static, instead it evolves in response to the ever-changing world of work. Some innovative legislative responses to current challenges include laws that require main companies to disclose and report on human and labour rights and conduct operations with due diligence vis-à-vis their subsidiaries and subcontracted undertakings. Labour clauses in procurement, although not conceptually new, play an increasingly important role in securing labour rights in the subcontracting and outsourcing chain. Other emergent legislative initiatives aim at mainstreaming OSH throughout all stages of education.

Moreover, some countries have departed from the employment relationship as a central element in determining who the duty and rights holders are (typically the “employer” and the “employees” respectively) to respond to an increasingly fragmented labour force. These have broadened

the scope of the application of their OSH laws by extending the concepts of “employer” and “employee”, so as to include respectively owners and occupiers, and self-employed, workers of subcontractors and agency workers. Some countries have opted to expand the employer’s general OSH duty to cover persons who are not in an employment relationship with that employer; while others have introduced ‘joint and several liability schemes’. Additionally, to adapt to changes in work organisation and working arrangements, there is a trend to no longer allocate responsibility of preventive action with the entity who controls the worker or workplace, but rather with the entity who has control over the work activity and is therefore in a situation of preventing harm.



OSH management systems have existed for several decades now and they have demonstrated their key role in successfully managing OSH and securing an optimal OSH performance in the workplace. Consequently, more and more countries are deciding to legally require undertakings to establish them. The ILO OSH-MS Guidelines (ILO-OSH 2001) are a useful tool that provides for a national management system and a workplace level management system. The ILO encourages countries to legally require the adoption of this management system, adding a rigor to these systems that other voluntary standards do not have. A number of countries have set up national frameworks to promote the implementation of the Guidelines or have adapted their own guidelines based upon them. Furthermore, some have developed national certification standards and auditing systems based on ILO-OSH 2001.

OSH management systems and systematic OHS management, do not cover workers in ‘non-standard’ forms of employment such as self-employment, platform work, hired labour and work in the informal economy. In other instances where the employment relationship may be weak – for instance, sub-contracting in global supply chains, for migrant workers, or workers on temporary or zero-hour contracts – OSH management may also be lacking. To address the concerns of the future of work, there is a need to understand, apply and extend the control logic of OSH management. This requires resources and training for OSH actors, including engineers, lawyers and medical personnel. Micro, small and medium- sized enterprises are too numerous for limited labour inspection resources to improve OSH, and intermediate actors should be strengthened. Increased supervision and sanctioning of auditors may be necessary to ensure that certificates are credible (Frick, 2019).



## Governance of OSH

As seen throughout this report, there has been a shift over the years in the instruments of governance from prescriptive regulation to that of the regulation of performance and process. This has influenced approaches to compliance to address the greater complexity of responsibilities for OSH created by global trends including outsourcing and the increased role of supply chains, as well as technology, demographic changes, climate change and new forms of work.

Labour inspectorates and other labour law regulatory mechanisms have adapted their operations to be able to effectively address these challenges. They moved from a “tick-the-box” inspection to a systemic or holistic view of the workplace. This means that all the different components of work and their interactions are considered and, rather than only addressing immediate shortcomings, inspectors look for the causes of corporate behaviour and engage in a process of influencing companies’ policies and management practices to obtain and maintain sustainable changes.

This approach requires authorities to make the best use of their resources by planning strategically in order to set priorities and select targets based on evidence. It demands that they think beyond the narrow focus of enforcement and embrace possibilities for improved compliance that stem from wider influences: behavioural, environmental, systemic, market-based, financial, institutional, political, legal, cultural, and beyond. It equally requires them to look into how the outcomes of inspection in a given company, including strict enforcement, may have a positive spill over effect in the sector, in companies with similar business models, or throughout value chains.

Equally, public and private stakeholders may wield influences that are more powerful and more sustainable to combat particular compliance issues than those of regulatory inspectorates. Harnessing those influences may therefore be one of the labour inspectorate’s most effective and sustainable compliance strategies.

Some of these issues and the responses required to respond to them are addressed in the recent guidance for national authorities published by the ILO concerning strategic compliance planning for labour inspectorates. The guidelines advise authorities to gain an understanding of the underlying causes of the problems they wish to address. This includes an exploration of what are the positive and negative influences on the organizations and individuals whose compliance behaviour they wish to impact, along with the interests of stakeholders who might benefit from their compliance, how their interests might be usefully targeted and what would be the most appropriate interventions to do so.

To be fully operational, labour inspectorates need to be provided with a set of necessary conditions including an adequate legal framework, providing to labour inspectors the mandate and prerogatives in line with the Labour Inspection Convention, 1947 (No. 81) and Labour Inspection (Agriculture) Convention, 1969 (No. 129). This also refers to the availability of material, human and financial resources, qualified staff and political support to allow for the operation of labour inspectorates and to ensure as a minimum, that the workplaces under their supervision are inspected as “often and thoroughly as is necessary to ensure the effective application of the relevant legal provisions”.<sup>33</sup>

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33 Article 16, Labour Inspection Convention, 1947 (No. 81).

These challenges were highlighted in the **ILO General Survey (2006)** and the **ILO Report on Labour Administration and Labour Inspection (2011)**. In the years since these reports were published, there is little to suggest that these concerns have been addressed, or that the need for labour inspectorates to be able to be flexible and responsive to changes in the organization and structure of work and workplaces has diminished. Rather, trends suggest that many governments may continue to reduce both public expenditure and regulatory controls, while the pace of change that inspectorates are required to understand and adapt to will continue to increase. These changes require consideration in policy responses to meeting the challenges for improving OSH in the future and to recognize the fundamental role of labour inspection to bring legislation into practice.



### ■ 3.6 Reinforcing the role of governments and social partners and expanding partnerships

With regard to workers' organizations, worker representation in health and safety committees is recognized to significantly improve OSH outcomes. The autonomous representation of workers' interests in OSH has been widely recognized as being associated with improved workplace OSH management arrangements and OSH outcomes among workers.<sup>34</sup> Tripartite representation of Governments, workers and employers is at the heart of the ILO's labour standards and instruments on OSH and effective social dialogue will continue to be crucial to address the safety and health concerns of the future, many of which are still unknown. Governments and social partners may increase efforts to organize workers that are not in formal employment relationships and promote awareness of OSH both in formal and informal work. In response for the need for governments, workers, employers and others to promote decent work, the ILO Global Commission on the Future of Work called for stakeholders to "take responsibility" for building a just and equitable future (ILO, 2019a).

Governments, workers' and employers' organizations are still the leading partners to implement the objective of safe and healthy working environments. Nevertheless, the ILO tripartite constituents have been increasingly collaborating with civil society institutions, OSH institutes, and active non-governmental organisation on OSH, public and private institutes and universities in the area of OSH. The link between OSH and public health has further implications on expanding partnerships to achieve the **2030 Agenda for Sustainable Development**. For example, INTEROSH<sup>35</sup> is a global database on agencies, institutions and organizations engaged in knowledge development, capacity enhancement and dissemination of information in the technical domain of OSH. INTEROSH aims to improve knowledge and information sharing around the world and support the development of new collaboration between stakeholders on priority topics of interest, including those relevant to the future of work and the topics discussed in this report.

Engaging the private sector is key, especially to help reach out to micro, small and medium enterprises (SMEs). There has been substantial growth in the proportion of SMEs and their position overall in the economies in many countries. SMEs are estimated to generate over 50 per cent of new jobs globally and hire more workers than large enterprises in most developing and emerging countries. Many of these workers are employed in the informal economy. Therefore, SMEs have great potential to contribute to worker safety and health and wellbeing, as well as economic and social development. Nevertheless, employment in SMEs is too often in low-paid, low-skilled jobs that lack decent working conditions. As part of the ILO's flagship programme on OSH (see section 1.5) the ILO implements a project to uphold sustainable delivery mechanisms to promote OSH in small and medium sized enterprises. Policies to improve OSH for SMEs can contribute greatly to workers safety and health and have the potential to improve the performance of SMEs and contribute to economic development (ILO, 2013b).

34 For comprehensive reviews of the literature on the role of worker representation in OSH see Walters 2006, Walters and Nichols 2007, Walters and Nichols 2009, Walters et al 2011, EU-OSHA 2017.

35 Available online at: <https://www.ilo.org/dyn/interosh/en/f?p=14100:1:::NO::>



## ■ Concluding remarks

The world of work is undergoing profound changes, not least the transformative effect of new technology, changing demographics and climate change and the shift towards the green economy. These changes will bring about new challenges and opportunities for the safety and health of the world's workers.

While work is crucial to the way we sustain our lives, lifts people out of poverty and gives many a sense of identity and purpose, it can also be dangerous and unhealthy if health and safety risks are not managed appropriately. It is important to work towards a future where the utmost is done to ensure the safety and health of the world's workers.

New risks may emerge whereas other risks may be on the rise. Of particular concern could be stress and psychosocial risks at work and the onset of non-communicable diseases resulting from lifestyle changes and coping habits. At the same time, many of the world's workers are challenged by persistent health risks, which require renewed focus and efforts to ensure a culture of prevention at work.

In January 2019, at the beginning of the ILO's centenary celebrations, the ILO Global Commission on the Future of Work called for a **Universal Labour Guarantee**, including fundamental workers' rights, an "adequate living wage", limits on hours of work and **ensuring safe and healthy workplaces**. The Commission also called for the **recognition of safety and health at work as a fundamental principle and right at work**.

While the road ahead presents many new challenges to safety and health at work, it is important for governments, employers and workers, and other stakeholders to seize the opportunities to create a safe and healthy future of work for all.



# References

- Adam-Poupart, A.; Labrèche, F.; Smargiassi, A.; Duguay, P.; Busque, M-A.; Gagné, C.; Rintamäki, H.; Kjellstrom, T.; Zayed, J. 2013. *Climate Change And Occupational Health And Safety In A Temperate Climate: Potential Impacts And Research Priorities In Quebec* (Canada. Industrial Health 2013, 51), pp. 68–78.
- Beers, H., 2016. *How AI could benefit the world of work and impact on OSH. Safety and Health Practitioner*. Available at: [http://www.shponline.co.uk/ai-benefit-world-work-impact-osh/?cid=homepage\\_1st&cid=ema-Marketing-10%20November%202016%20-%20SHP%20Daily%20Update-CTA-](http://www.shponline.co.uk/ai-benefit-world-work-impact-osh/?cid=homepage_1st&cid=ema-Marketing-10%20November%202016%20-%20SHP%20Daily%20Update-CTA-)
- Beham, B.; Prag, P.; Drobnic, S. 2012. “Who’s got the balance? A study of satisfaction with the work– family balance among part-time service sector employees in five western European countries”, in *International Journal of Human Resource Management*, Vol. 23, No. 18, pp. 3725–3741.
- Bena, A.; Berchialla, P.; Debernardi, M.; Pasqualini, O.; Farina, E.; Costa, G. 2011. “Impact of organization on occupational injury risk: Evidence from high-speed railway construction”, in *American Journal of Industrial Medicine*, Vol. 54, No. 6, pp. 428–437.
- Berg, J., 2016. *Income security in the on-demand economy: Findings and policy lessons from a survey of crowdworkers*. ILO Conditions of Work and Employment Series 74. Geneva. p. 1.
- Biewald, L., 2015. *Artificial intelligence and the future of work*. Available at: <https://medium.com/the-wtf-economy/artificial-intelligence-and-the-future-of-work-a0eaabea7c41#.l6npsgsll>
- BIM Plus, 2017. *How drones can help monitor health and safety on site*. Available at: <http://www.bimplus.co.uk/analysis/how-drones-can-help-monitor-health-and-safety/>
- Carson, W.G. 1979. “The conventionalisation of early factory crime”, *International Journal of the Sociology of Law*, 7:370-60.
- Centers for Disease Control and Prevention, CDC. 2010. “Occupational injuries and deaths among younger workers: United States, 1998--2007” in *Morbidity and Mortality Weekly Report* (MMWR), vol. 59, no. 15, pp. 449-455, April 2010.
- Christopher, P.; Murray, J. 2016. “Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015”. *Lancet*, 388:1459-544.
- Cox, A.; Fletcher, L.; Rhisiart, M., 2014. *Scoping study for a foresight on new and emerging occupational safety and health (OSH) risks and challenges*. EU-OSHA, Bilbao
- Dakota Software, 2019. *Drones and EHS Management Part 1: Agency Inspections*. Available at: <https://www.dakotasoft.com/blog/2019/01/03/drones-and-ehs-management-part-1-agency-inspections>
- Dewe, P.; Kompier, M. 2008. *Wellbeing and work: Future challenges*. The Government Office for Science, London.
- Driscoll, T. 2018. “The 2016 global burden of disease arising from occupational exposures” in *Occupational and Environmental Medicine*, 75(Suppl 2): A1–A650.
- EHS Today, 2014. *The Triangle Shirtwaist Factory Fire – March 25, 1911 [Photo Gallery]*. Available at: <https://www.ehstoday.com/safety/triangle-shirtwaist-factory-fire-march-25-1911-photo-gallery>
- Engkvist, I.-L.; Svensson, R.; Eklund, J. 2011. “Reported occupational injuries at Swedish recycling centres– based on official statistics”. *Ergonomics* 54(4):357–366.
- Eurofound and ILO: *Working anytime, anywhere. 2017. The effects on the world of work* (Luxembourg).
- European Agency for Safety and Health at Work (EU-OSHA). 2007. *OSH in figures: Young workers - Facts and figures. European risk observatory report* (Luxembourg).



—. 2013. *New risks and trends in the safety and health of women at work* (Bilbao). Available at: <https://osha.europa.eu/en/publications/reports/new-risks-and-trends-in-the-safety-and-health-of-women-at-work/view>

—. 2015. *A review on the future of work: robotics* (Bilbao). Available at: <https://osha.europa.eu/en/tools-and-publications/publications/future-work-robotics/view>

—. 2017. *Monitoring technology: the 21st century's pursuit of well-being?* (Bilbao) Available at: <https://osha.europa.eu/en/tools-and-publications/publications/monitoring-technology-workplace/view>

—. 2017. *Worker participation in the management of occupational safety and health: qualitative evidence from ESENER 2*. Available at: <https://osha.europa.eu/en/tools-and-publications/publications/worker-participation-management-occupational-safety-health/view>

—, 2018a. *Safety and health in micro and small enterprises in the EU: final report from the 3-year SESAME project* (Bilbao). Available at: <https://osha.europa.eu/en/tools-and-publications/publications/safety-and-health-micro-and-small-enterprises-eu-final-report-3/view>

—, 2018b. *Foresight on new and emerging occupational safety and health risks associated with digitalisation by 2025* (Bilbao). Available at: <https://osha.europa.eu/en/tools-and-publications/publications/foresight-new-and-emerging-occupational-safety-and-health-risks/view>

European Commission. No date. *Nanomaterials*. Available at: [http://ec.europa.eu/growth/sectors/chemicals/reach/nanomaterials\\_en](http://ec.europa.eu/growth/sectors/chemicals/reach/nanomaterials_en)

—. 2018. *Definition of a nanomaterial*. Available at: [http://ec.europa.eu/environment/chemicals/nanotech/faq/definition\\_en.htm](http://ec.europa.eu/environment/chemicals/nanotech/faq/definition_en.htm)

European Parliament. 2017. The social protection of workers in the platform economy, Study for the EMPL Committee, IP/A/EMPL/2016-11, Directorate General for Internal Policies (Brussels).

European Trade Union Institute. 2017. "The future of work in the digital era" in *The European Trade Union Institute's (ETUI) health and safety at work magazine*. Available at: <https://www.etui.org/Topics/Health-Safety-working-conditions/HesaMag/The-future-of-work-in-the-digital-era>

Fabiano, B.; Currò, F.; Reverberi, A.P.; Pastorino, R. 2008. "A statistical study on temporary work and occupational accidents: Specific risks and risk management strategies", in *Safety Science*, Vol. 46, No. 3, pp. 535–544.

Farrell, D.; Greig, F. 2017. *The online platform economy: Has growth peaked?* (Washington, DC, JPMorgan Chase Institute).

*Financial Times*, 2016. "Wearable devices aim to reduce workplace accidents". Available at: <https://www.ft.com/content/d0bfea5c-f820-11e5-96db-fc683b5e52db>

*Financial Times*, 2017. "IoT-linked wearables will help workers stay safe". Available at: <https://www.ft.com/content/944e6efe-96cb-11e7-8c5c-c8d8fa6961bb>

Fingas, R. 2015. *IBM adopts Apple Watch for internal fitness initiative & Watson-linked health app*. Available: <http://appleinsider.com/articles/15/10/27/ibm-adopts-applewatch-for-internal-fitness-initiative-watson-linked-healthapp>

Fogarty, J; McCally, M. 2010. "Health and safety risks of carbon capture and storage". *JAMA*. 303(1):67–8.

Fortune, M.K.; Mustard, C.A.; Etches, J.J.; Chambers, A.G. 2013. "Work-attributed Illness Arising From Excess Heat Exposure in Ontario, 2004–2010". *Public Health* 104(5):e420–e426.

Frey, C.B.; Holmes, C.; Osborne, M.A.; Rahbari, E.; Garlick, R.; Friedlander, G.; McDonald, G.; Curmi, E.; Chua, J.; Chalif, P.; Wilkie, M. 2016. *Technology at work v2.0: The future is not what it used to be* (Oxford Martin, Oxford).

Frick, K. 2019. *Critical perspectives on OSH management systems and the future of work*.

Gakidou, E.; Afshin, A.; Abajobir, A.; Abate, K.; Abbafati, C.; Abbas, K.; Abd-Allah, F.; Abdulle, A.; Abera, S.; Aboyans, V.; Abu-Raddad, L. 2017. "Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016". *The Lancet*, 390(10100): 1345-1422.

- Garben, S. 2017. *Protecting Workers in the Online Platform Economy: An overview of regulatory and policy developments in the EU* (EU-OSHA, Bilbao).
- GDB/Lancet. 2018. Database available at: <https://vizhub.healthdata.org/gbd-compare/>
- Gordon, C.J. 2003. "Role of environmental stress in the physiological response to chemical toxicants". *Environ. Res.* 92(1):1–7.
- Government of Canada. 2017. *Halifax Explosion*. Available at: [https://www.canada.ca/en/parks-canada/news/2017/12/halifax\\_explosion.html](https://www.canada.ca/en/parks-canada/news/2017/12/halifax_explosion.html)
- Graham, M.; Hjorth, I.; Lehdonvirta, V. 2017. "Digital labour and development: Impacts of global digital labour platforms and the gig economy on worker livelihoods". *European Review of Labour and Research*, Vol. 23, No. 2, pp. 135–162
- Grimshaw, D.; Johnson, M.; Rubery, J. et al. 2016. *Reducing Precarious Work - Protective gaps and the role of social in Europe* (European Commission project (DG Employment, Social Affairs and Equal Opportunities VP/2014/004, Industrial Relations & Social Dialogue. European Work and Employment dialogue Research Centre, University of Manchester, UK).
- Guardian, 2018. "Amazon patents wristband that tracks warehouse workers' movements". Available at: <https://www.theguardian.com/technology/2018/jan/31/amazon-warehouse-wristband-tracking>
- Gubernot, D.M.; Anderson, G.B.; Hunting, K.L. 2014. "The epidemiology of occupational heat exposure in the United States: a review of the literature and assessment of research needs in a changing climate" in *International Journal of Biometeorology*. 58(8): 1779–88.
- Hämäläinen, P.; Takala, J.; Boon Kiat, T. 2017. *Global Estimates of Occupational Accidents and Work-related Illnesses 2017* (XXI World Congress on Safety and Health at Work, Singapore, Workplace Safety and Health Institute).
- Hambach, R.; Droste, J.; François, G. et al. 2012. "Work-related health symptoms among compost facility workers: a cross-sectional study". *Arch. Publ. Health* 70(13):0778–0736(2012).
- Hong E. 2015. *Making it work: A closer look at the gig economy* (Pac Standard).
- Hughes, S.; Haworth, N. 2011. *The International Labour Organization (ILO): Coming in from the Cold* (Routledge, London).
- IBM. 2016. *What is Watson?*, Available at: <http://www.ibm.com/smarterplanet/us/en/ibmwatson/what-is-watson.html>
- International Labour Office. 1987. *General Survey of the Reports on the Guarding of Machinery Convention (No. 119) and Recommendation (No. 118), 1963, and on the Working Environment (Air Pollution, Noise and Vibration) Convention (No. 148) and Recommendation (No. 156), 1977. Report III* (Part 4B), International Labour Conference, 73rd Session, Geneva, 1987.
- . 2006. *Occupational Safety and Health: synergies between security and productivity* (Geneva).
- . 2012. *Promoting safety and health in a green economy* (Geneva).
- . 2013. *Labour migration and development: ILO moving forward, background paper for discussion at the ILO Tripartite Technical Meeting on Labour Migration* (Geneva).
- . 2013b. *Can better working conditions improve the performance of SMEs? An international literature review* (Geneva).
- . 2014. *Occupational safety and health (OSH) in the informal economy* (Geneva). Available online at: [https://www.ilo.org/wcmsp5/groups/public/---ed\\_protect/---protrav/---safework/documents/publication/wcms\\_313828.pdf](https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_313828.pdf)
- . 2016a. *Non-standard employment around the world: Understanding challenges, shaping prospects* (Geneva). Available at: [https://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms\\_534326.pdf](https://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_534326.pdf)
- . 2016b. *Women at Work: Trends 2016* (Geneva). Available at: [https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms\\_457317.pdf](https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_457317.pdf)
- . 2016c. *OSH in Global Supply Chains - Fact Sheet* (Geneva). Available at: [https://www.ilo.org/safe-work/projects/WCMS\\_522952/lang-en/index.htm](https://www.ilo.org/safe-work/projects/WCMS_522952/lang-en/index.htm)

- . 2017a. *The Standards Initiative: Report of the third meeting of the Standards Review Mechanism Tripartite Working Group*. Governing Body 331st Session, Geneva, 26 October–9 November 2017. GB.331/LILS/2.
- . 2017b. *The Threat of Physical and Psychosocial Violence and Harassment in Digitalized Work* (Geneva). Available at: [https://www.ilo.org/actrav/info/pubs/WCMS\\_617062/lang--en/index.htm](https://www.ilo.org/actrav/info/pubs/WCMS_617062/lang--en/index.htm)
- . 2018a. *The impact of technology on the quality and quantity of jobs* (Geneva). Available at: [https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms\\_618168.pdf](https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms_618168.pdf)
- . 2018b. *Job quality in the platform economy* (Geneva). Available at: [https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms\\_618167.pdf](https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms_618167.pdf)
- . 2018c. *Greening with jobs* (Geneva). Available at: <https://www.ilo.org/global/research/global-reports/weso/greening-with-jobs/lang--en/index.htm>
- . 2018d. *World employment and social outlook: Trends 2018* (Geneva). Available at: [https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms\\_615594.pdf](https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_615594.pdf)
- . 2018e. *Digital labour platforms and the future of work: Towards decent work in the online world* (Geneva). Available online at: [https://www.ilo.org/global/publications/books/WCMS\\_645337/lang--en/index.htm](https://www.ilo.org/global/publications/books/WCMS_645337/lang--en/index.htm)
- . 2018f. *Improving the Safety and Health of Young Workers* (Geneva).
- . 2018g. *The Standards Initiative: Report of the fourth meeting of the Standards Review Mechanism Tripartite Working Group*. Governing Body 334th Session, Geneva, 25 October–8 November 2018. GB.334/LILS/3
- . 2018h. *ILO Global Estimates on International Migrant Workers: Results and methodology* (Geneva, 2018)
- . 2019a. *Work for a brighter future* (Global Commission on the Future of Work, Geneva).
- . 2019b. *A quantum leap for gender equality. For a better future of work for all* (Geneva).
- . In Press. *Working on a Warmer Planet: The Impact of Heat Stress on Labour Productivity and Decent Work*. (Geneva).
- Independent, 2015. “Worker killed by robot at Volkswagen car factory”. Available at: <https://www.independent.co.uk/news/world/europe/worker-killed-by-robot-at-volkswagen-car-factory-10359557.html>
- Jeske, T. 2016. “Opportunities and challenges of digitalization for occupational safety and health”. (Kommission Arbeitsschutz und Normung). Available online: <https://www.kan.de/en/publications/kanbrief/digitalization-and-industry-40/opportunities-and-challenges-of-digitalization-for-occupational-safety-and-health/>
- Julander, A.; Lundgren, L.; Skare, L. et al. 2014. Formal recycling of e-waste leads to increased exposure to toxic metals: An occupational exposure study from Sweden. *Environ.Int.* 73:243–251.
- Kachaiyaphum, P.; Howteerakul, N.; Jujirarat, D.; Siri, S.; Suwannapong, N. 2010. “Serum cholinesterase levels of Thai chilli farm-workers exposed to chemical pesticides: Prevalence estimates and associated factors”, in *Journal of Occupational Health*, Vol. 52, No. 1, pp. 89–98.
- Kemmlert, K; Lundholm, L. 2001. “Slips, trips and falls in different work groups – with reference to age and from a preventive perspective” in *Applied Ergonomics*. 32:149–153. doi: 10.1016/S0003-6870(00)00051-X.
- Keifer, M.; Rodríguez-Guzmán, J.; Watson, J.; van Wendel de Joode, B.; Mergler, D.; Soares da Silva, A. 2016. “Worker health and safety and climate change in the Americas: issues and research needs”. *Rev Panam Salud Publica*. 2016;40(3):192–97.
- Kjellstrom, T.; Sawada, S.; Bernard, T.E.; Parsons, K.; Rintamäki, H.; Holmér, I. 2013. “Climate change and occupational heat problems”. *Ind Health* 51(1):1–2.
- Kjellstrom, T.; Otto, M.; Lemke, B.; Hyatt, O.; Briggs, D.; Freyberg, C.; Lines, L. 2016. *Climate Change And Labour: Impacts Of Heat In The Workplace Climate Change, Workplace Environmental Conditions, Occupational Health Risks, And Productivity – An Emerging Global Challenge To Decent Work, Sustainable Development And Social Equity*. UNDP.
- Kjellstrom, T. 2016. “Impact of climate conditions on occupational health and related economic losses a new feature of global and urban health in the context of climate change” in *Asia Pac .J. Publ. Health* 28 (2Suppl): 28S–37S.

- Lamontagne, A.; Smith, P.; Louie, A.; Quinlan, M.; Shoveller, J.; Ostry, A. 2009. "Unwanted sexual advances at work: Variations by employment arrangement in a sample of working Australians", in *Australian and New Zealand Journal of Public Health*, Vol. 33, No. 2, pp. 173–179.
- Leon, L.R. 2008. "Thermoregulatory responses to environmental toxicants: The interaction of thermal stress and toxicant exposure" in *Toxicol. Appl. Pharmacol.* 233(1): 146–161.
- Lundgren, K; Kuklane, K; Gao, C; Holmér, I. 2013. "Effects of heat stress on working populations when facing climate change" in *Ind Health* 51(1):3–15.
- Luxon, S.J. 1984. "A History of Industrial Hygiene" in *American Industrial Hygiene Association Journal*, 45:11,731-739.
- Maciejewski, M.; Dimova, M. 2016. *The ubiquitous digital single market, Fact Sheets on the European Union*. Available at: [http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuld=FTU\\_5.9.4.html](http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuld=FTU_5.9.4.html)
- Maheshrengaraj, R.; Vinodkumar, M. 2014. "A study on influence of individual factors, precarious employment in work injury exposures among welders employed in organised sector fabrication units", in *International Journal of Design and Manufacturing Technology*, Vol. 5, No. 3, pp. 160–166.
- Markowitz, Gerald; Rosner, David. 2013. *Deceit and Denial: The Deadly Politics of Industrial Pollution*. (Berkeley, California Press: University of California Press) p. 185.
- Mazloumi, A; Golbabaie, F; Mahmood Khani, S.; Kazemi, Z; Hosseini, M; Abbasinia, M et al. 2014. "Evaluating effects of heat stress on cognitive function among workers in a hot industry" in *Health Promot Perspect.* 2014;4(2):240–6.
- McCulloch, J.; Rosental P-A. 2017. "Johannesburg and Beyond; Silicosis as a transnational and Imperial Disease 1900-1940" in Rosental, P-A (ed) *Silicosis: A World History* (Johns Hopkins University Press, Baltimore).
- McNamee, R.; Kemmlert, K.; Lundholm, L.; Cherry, N. M. 1997. "Injuries after falls at work in the United Kingdom and Sweden with special reference to fractures in women over 45" in *Occupational and Environmental Medicine*, 54(11), pp. 785-792.
- McInnes, J.A.; MacFarlane, E.M.; Sim, M.R.; Smith, P. 2018. *The impact of sustained hot weather on risk of acute work-related injury in Melbourne, Australia*. *International journal of biometeorology*, 62(2), pp. 153-163.
- McNamee, R; Kemmlert K; Lundholm, L; Cherry, N.M. 1997. Injuries after falls at work in the United Kingdom and Sweden with special reference to fractures in women over 45 in *Occup Environ Med* 54:785–792.
- Murray C.; Lopez A. 1996. "The Global Burden of Disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020". *Global Burden of Disease and Injury Series*, Vol. 1. (Cambridge, MA: Harvard Sch. Public Health/WHO/World Bank).
- National Museum Wales, no date. *Miners lives at 5½p each: The Government Enquiry into the 1913 Senghenydd mine disaster*. Available at: <https://museum.wales/articles/2012-07-06/Miners-lives-at-5p-each-The-Government-Enquiry-into-the-1913-Senghenydd-mine-disaster/>
- Neira, M.; Legros, D.; Ivanov, I.D. 2010. "Global environmental change: opportunities and challenges for occupational health" in *Ital. J. Occup. Environ. Hyg.*, 1(2): 76 – 77.
- Nelson, D.; Nelson R.; Concha-Barrientos, M.; Fingerhut, M. 2005. "The Global Burden of Occupational Noise-Induced Hearing Loss" in *Journal of Industrial Medicine*, 48:446–458.
- NHS Employers. 2018. *Regular personalised risk assessments*. Available at: <https://www.nhsemployers.org/your-workforce/retain-and-improve/staff-experience/health-and-wellbeing/protecting-staff-and-preventing-ill-health/partnership-working-across-your-organisation/hswpg-resources/working-longer-in-the-nhs/job-design/risk-assessments>
- Nilsson, M.; Kjellstrom, T. 2010. "Climate change impacts on working people: how to develop prevention policies" in *Global Health Action*, 3(1), 5774.
- Odgerel, C.; Takahashi, K.; Sorahan, T.; Driscoll, T.; Fitzmaurice, C.; Yoko, M.; Sawanyawisuth, K.; Furuya, S.; Tanaka, R.; Horie, S.; van Zandwijk, N.; Takala J. 2017. "Estimation of the global burden of mesothelioma deaths from incomplete national mortality data" in *Occupational and Environmental Medicine*, 74:851–858.

- OECD. 2016. *The Economic Consequences of Outdoor Air Pollution (Paris)*. Available online at: <http://www.oecd.org/environment/the-economic-consequences-of-outdoor-air-pollution-9789264257474-en.htm>
- Olson, P. 2014. *Wearable tech is plugging into health insurance*. Available at: <http://www.forbes.com/sites/parmyolson/2014/06/19/wearable-tech-health-insurance/>
- Pollack, E. 2012. Counting up to green: Assessing the green economy and its implications for growth and equity in *Econ. Policy Instit. Briefing Paper* Issue 349, October 9 2012.
- Prassl J.; Risak M. 2016. Uber, Taskrabbit and Co: “Platforms as employers? Rethinking the legal analysis of crowdwork” in *Comparative Labour Law and Policy Journal*, available at: <http://labourlawresearch.net/papers/uber-taskrabbit-co-platforms-employers-rethinking-legal-analysis-crowdwork>
- Punnett L.; Prüss-Üstün A.; Nelson, D.; Fingerhut, M.; Leigh, J.; Tak, S.; Phillips, S. 2005. “Estimating the Global Burden of Low Back Pain Attributable to Combined Occupational Exposures” in *American Journal of Industrial Medicine*, 48:459–469.
- Pupos, V.E.V. 2014. “From standard to non-standard employment: the changing patterns of work in Vietnam”, in M.R. Serrano (ed.), pp. 139–163.
- Quinlan M.G. 2006, “Contextual Factors Shaping the Purpose of Labour Law: A Comparative Historical Perspective” in Arup, C.; Gahan, P.; Howe, J.; Johnstone, R.; Mitchell, R.; O’Donnell, A. (ed.), *Labour Law and Labour Market Regulation: Essays on the Construction, Constitution and Regulation of Labour Markets and Work Relationships*, edn. 1, Federation Press, Sydney, pp. 21 – 42.
- Quinlan, M.G. 2017. *The Origins of Worker Mobilisation: Australia 1788-1850* (1st Edition. Routledge, London).
- Quinlan, M.; Bohle, P. 2008. “Under pressure, out of control, home alone? Reviewing research and policy debates on the OHS effects of outsourcing and home-based work” in *International Journal of Health Services*, 38, 489-525.
- Quinlan, M.; Mayhew, C.; Bohle, P. 2001. “The global expansion of precarious employment, work disorganization and occupational health: A review of recent research evidence” in *International Journal of Health Services*, 31, 335-414.
- Reinert, D., 2016. *Editorial: The future of OSH: a wealth of chances and risks*. NIOSH.
- Risak M.; Warter J. 2015. *Legal strategies towards fair employment conditions in the virtual sweatshop*. (Conference Paper presented at the Regulating for Decent Work 2015 Conference, Geneva). Available at: [http://www.rdw2015.org/uploads/submission/full\\_paper/373/crowdwork\\_law\\_RisakWarter.pdf](http://www.rdw2015.org/uploads/submission/full_paper/373/crowdwork_law_RisakWarter.pdf).
- Robens, A (Lord). 1972. *Safety and health at work*. Report of the Committee, 1970-72 (Vol. 1). HM Stationery Office.
- Robert, M. 1973. “The International Occupational Safety and Health Information Centre: The CIS”, in *Annals of Occupational Hygiene*, Vol. 16, No. 3, pp. 267-273 [CIS 74-2094].
- Rodgers, G.; Lee, E.; Swepston, L.; and Van Daele. 2010. *The ILO and the Quest for Social Justice* (Geneva).
- Rushton, L. 2017. “The Global Burden of Occupational Disease” in *Current Environmental Health Report*, 4:340–348
- Schall, M.; Fethke, N.; Roemig, V. 2018. “Digital Human Modeling in the Occupational Safety and Health Process: An Application in Manufacturing” in *IIE Transactions on Occupational Ergonomics and Human Factors*, DOI: 10.1080/24725838.2018.1491430
- Schechter, A.; Colacino, J.A.; Harris, T.R.; Shah, N.; Brummitt, S.I. “A newly recognized occupational hazard for US electronic recycling facility workers: polybrominated diphenyl ethers” in *J. Occup. Environ. Med.* 51(4):435–440(2009).
- Schulte P.; Chun, H. 2009. “Climate change and occupational safety and health: establishing a preliminary framework” in *J Occup Environ Hyg.* 2009 Sep;6(9):542-54.
- Schulte, P.A.; Heide, D.; Okun, A.; Branche, C. 2010. “Making green jobs safe” in *Indust. Health* 48(4):377–379.
- Schwab, K. 2016. The fourth industrial revolution (World Economic Forum, Cologny).
- Schweder, P. 2009. *Occupational health and safety of seasonal workers in agricultural processing*, PhD thesis (Sydney, University of New South Wales).



- Serrano, M.R. (ed.). 2014. *Between flexibility and security: The rise of non-standard employment in selected ASEAN countries* (Jakarta, ASEAN Services Employees Trade Unions Council ASETUC).
- Stacey, N.; Bradbrook S.; Reynolds J.; Williams, H. 2016. *Review of trends and drivers of change in information and communication technologies and work location* (EU-OSHA, Bilbao).
- Stacey, N.; Ellwood, P.; Bradbrook, S.; Reynolds, J.; Williams, H. 2017. *Key trends and drivers of change in information and communication technologies and work location Foresight on new and emerging risks in OSH* (EU-OSHA, Bilbao).
- Steijn, W.; Luijff, E.; van der Beek, D. 2016. *Emergent risk to workplace safety as a result of the use of robots in the work place* (TNO, Utrecht).
- Sumner, S.A.; Layde, P.M. 2009. "Expansion of renewable energy industries and implications for occupational health" in *JAMA*. 2009;302(7):787–9.
- SUVA. 2011. Prospective 2029: *Etude sur les futurs risques d'accidents et de maladies professionnelles et les opportunités de prévention*. Available at: <https://extra.suva.ch/webshop/50/5032DFB54DA837E0E10080000A630358.pdf>
- Takala, J.; Härmäläinen, P.; Nenonen, N.; Takahashi, K.; Odgerel, C.; Rantanen, J. 2017. "Comparative Analysis of the Burden of Injury and Illness at Work in Selected Countries and Regions" in *Central European Journal of Occupational and Environmental Medicine*, 23(1-2):6-31.
- Takala, J.; Härmäläinen, P.; Saarela, K.; Yun, L.; Manickam, K.; Jin, T.; Heng, P.; Tjong, C.; Kheng, L.; Lim, S.; Lin, G. 2014. "Global Estimates of the Burden of Injury and Illness at Work in 2012" in *Journal of Occupational and Environmental Hygiene*, 11(5):326-337.
- Takala, J. 1998. "Resources: Information and OSH" in *Encyclopedia of Occupational Safety and Health*, Chapter 22.
- Tawatsupa, B.; Yiengprugsawan, V.; Kjellstrom, T.; Berecki-Gisolf, J.; Seubsman, S.A.; Sleight, A. "Association between heat stress and occupational injury among Thai workers: findings of the Thai Cohort Study" in *Ind Health*. 2013;51(1):34–46.
- Tsuno, K.; Kawakami, N.; Tsutsumi, A.; Shimazu, A.; Inoue, A.; Odagiri, Y.; Yoshikawa, T.; Haratani, T.; Shimomitsu, T.; Kawachi, I. 2015. "Socioeconomic determinants of bullying in the workplace: A national representative sample in Japan", in *PLoS ONE*, Vol. 10, No. 3.
- Tsydenova, O.; Bengtsson, M. 2011. "Chemical hazards associated with treatment of waste electrical and electronic equipment" in *Waste Manage* 31(1):45–58.
- Ujita, Y.; Douglas, P.J.; Adachi, M. 2019. "Enhancing the health and safety of migrant workers" in *Journal of Travel Medicine*, 26 (2): 1-3.
- UNEP/ILO/IOE/ITUC. 2008. *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*. Available at: [http://www.unep.org/labour\\_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf](http://www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf)
- UNDP. 2016. *Climate change and labor: impacts of heat in the workplace*. Available at: <http://www.undp.org/content/undp/en/home/librarypage/climate-and-disaster-resilience-/tackling-challenges-of-climate-change-and-workplace-heat-for-dev.html>
- Vanek, J.; Chen, M.A.; Carré, R.; Heintz, J.; Hussmanns, R. 2014. *Statistics on the Informal Economy: Definitions, Regional Estimates & Challenges*. WIEGO Working Paper (Statistics) No 2.
- Vega-Ruiz, M.L. 2014. Building OSH for nonstandard workers: general review, unpublished.
- Walters, D.; Johnstone, R.; Frick, K.; Quinlan, M.; Baril-Gingras, G.; Thebaud-Mony, A. 2011. *Regulating Workplace Risks: A Comparative Study of Inspection Regimes in Times of Change*. Cheltenham: Edward Elgar.
- Walters, D.; Nichols T. (eds.) 2009. *Workplace Health and Safety: International Perspectives on Worker Representation*. Basingstoke: Palgrave Macmillan.
- Walters, D.; Nichols, T. 2007. *Worker Representation and Workplace Health and Safety*, Palgrave Macmillan, Basingstoke.
- Walters, D.R. 1996. Trade unions and the effectiveness of worker representation in health and safety in Britain in *International Journal of Health Services*, 26(4): 625-641.

Weindling, P. 1995. "Social medicine at the League of Nations Health Organization and the International Labour Office compared" In: P. Weindling (Author), *International Health Organizations and Movements, 1918–1939* (Cambridge Studies in the History of Medicine, pp. 134-153). Cambridge: Cambridge University Press.

World Health Organization (WHO). 2012. Health in the green economy - occupational health (Geneva).

World Health Organization (WHO). 2018. Preventing disease through a healthier and safe workplace. (Geneva)

Yassaee, M.; Winter, R. 2017. *Analyzing affordances of digital occupational health systems*. Proceedings of the 50th Hawaii International Conference on System Sciences.

Yu, I.J.; Gulumian, M.; Shin, S.; Yoon, T.H.; Murashov, V., 2015. "Occupational and environmental health effects of nanomaterials" in BioMed research international.



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