HSE is proud of its record in protecting people at work. Sustaining this record in a rapidly changing world relies on keeping pace with change, to enable us to anticipate new health and safety challenges so that we continue to regulate proportionately and effectively. Science and evidence play a key role in this, not only by helping us tackle existing workplace health and safety issues, but, through the work of our Foresight Centre, to consider and challenge our thinking around the future world of work. We are therefore delighted to present our third annual Foresight Report. This report brings together a selection of the most significant issues affecting the workplace of the future, identified from our Foresight Centre’s horizon scanning activities during 2017/18.

The purpose of foresight activity is not to predict the future, but to highlight issues. Foresight challenges us, and others in the health and safety system, to consider what the changes in the world around us might mean for workplace health and safety. Foresight is a thought-starter; a prompt for us to reflect on the possible, revisit our assumptions and ask the ‘So what?’ question. This year, to link in with HSE’s Health and Work Strategy, our Foresight Report seeks to stimulate thinking around preventing ill health at work, particularly in our priority areas of occupational lung disease, musculoskeletal disorders (MSDs) and work-related stress.

We very much hope you enjoy reading this report and that you find it thought-provoking. The world of work is changing—we should ask: ‘So what, for worker health?’

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Chief Scientific Adviser and Director of Research

Professor David Fishwick
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Foreword

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The future world of work: implications for health and the workplace

The rise of technology and demographic shift are increasingly transforming our lives. The pace of technological change is accelerating; the scale, speed and impact of these changes is faster than in the past. Advances in information and communication technology are transforming the workplace, changing the nature of businesses, work sectors, occupations, work tasks and how people perceive work.

In terms of demographic shift, the UK’s population is getting older and for the first time, older people will outnumber children. More people are likely to work into older age and with pre-existing ill health conditions.

Making a difference to worker health requires the efforts of the whole health and safety system. Through HSE’s Health and Work Strategy we aim to prevent occupational ill health through our regulatory activity and by working with others, acting as an enabler and encouraging others to take ownership of health and safety. As part of this, we help to anticipate and highlight emerging issues that are likely to impact on the future world of work.

An understanding of the changing landscape as it affects the workplace, and the consequences for occupational health, is vital to inform future preventive measures, regulatory approaches and the provision of occupational health services.

HSE’s Foresight Centre chose the topics for this report based on the visible and emerging issues we observe through our routine horizon scanning activities. We focus on the impact of these issues on occupational health, highlighting in particular where there may be consequences for occupational lung disease, MSDs and work-related stress. The report describes the issues anticipated to make an impact over the coming four to ten years. The report does not attempt to cover every aspect in this vast sphere, but rather to provide a starting point for consideration.

The health and safety system in Great Britain aims to ensure that risks in the changing workplace are properly managed. One of the six strategic themes in the Help Great Britain Work Well Strategy (2016) is Keeping Pace with Change: anticipating and tackling new health and safety challenges. HSE’s Foresight Centre undertakes futures activities that contribute to the strategic themes. We identify emerging issues and consider their potential to affect health and safety. When HSE’s futures capability is combined with its unrivalled knowledge and expertise of health and safety, it can help Great Britain to tackle the anticipated problems of tomorrow, today.

Dr Patrick Vallance, the government’s Chief Scientific Adviser (GCSA) defines horizon scanning as, ‘A systematic examination of information to identify potential threats, risks, emerging issues and opportunities, beyond the Parliamentary term, allowing for better preparedness and the incorporation of mitigation and exploitation into the policy-making process.’ Futures techniques do not predict the future, but rather they provide decision-makers with the opportunity to build resilience to the changing future occupational landscape. This aligns with the government’s aim to help businesses grow and to do so in a healthy, safe and productive way.
Artificial intelligence (AI) can be defined as a branch of computer science concerned with creating more ‘intelligent’ machines. AI technologies have been developed to work in a more human-like way including:

- Learning
- Problem-solving
- Planning

Machine learning is an important area of AI, which involves training computers to learn tasks based on repeatedly working through examples. This allows computers to spot patterns in large amounts of data, without supervision.

AI has advanced rapidly over recent years, most notably as personal assistants in electronic devices such as mobile phones and smart speakers.

AI is increasingly being used for a range of activities including: driving, clinical diagnosis, translation, providing advice, legal casework, warehousing, loan approval, improving productivity and the efficiency of logistics operations. Advances in AI are developing rapidly and systems are growing more powerful and capable of carrying out a wider range of tasks.
Implications for health and the workplace

- There is evidence that work is being increasingly coordinated and overseen by computer algorithms, so workers may experience or perceive a loss of control over the pace, scheduling and way they do their work. These systems could prioritise productivity without adequately considering the impact on human workers. This may result in work intensification; which is linked to work-related stress, poor health and well-being, lower productivity and increased sickness absence. Increasingly, worker productivity data can also be used to reward, or penalise and exclude workers.

- AI could be used to analyse large volumes of past data, for example occupational health surveillance data, and potentially identify new insights into workplace ill health. This could flag up potential health problems at work before they become an issue. AI-generated workplace health guidance and advice could be delivered through smart devices such as a ‘chat-bot’ or personal protection systems.

- New insights produced by AI may be limited by the quality of available workplace health data. Inherent biases may also be present in the data used to train algorithms or in the structuring of the algorithms. There is, therefore, the potential for algorithms to draw erroneous conclusions from pattern analysis.

- The use of AI raises a number of ethical issues. Potentially sensitive health data needs to be protected. Consideration needs to be made of who is responsible when AI is used to support decision-making. For example, when AI is continually learning and modifying its own behaviour, it can be difficult to verify how the machine arrives at the decisions.

- A lack of understanding of how AI works and how it arrives at decisions could be a source of concern for workers and have an adverse impact on their mental health.
Handing over control: autonomous and unmanned technology

Autonomous vehicles (AV), also known as self-driving, driverless or unmanned vehicles including aerial systems such as drones, can be equipped with an array of powerful technology (e.g. RADAR, lasers, cameras, global positioning system (GPS) computers, AI and 3D maps). This enables AV to sense, monitor and navigate their environment. They can be remotely controlled or operate without human supervision or input.

Many modern vehicles are already equipped with assistive-driving features, such as cruise control, assisted parking etc. The transition to full autonomy is likely to be introduced in phases. Vehicles will become smarter and increasingly automated, requiring less human input.

Semi-autonomous cars and lorries are already undergoing trials in some cities in the UK, however some experts anticipate the transition to full AV on public roads could take up to ten years. Challenges such as vehicle regulation, infrastructure adaptation, public acceptance and legal liability will need to be addressed before AV are considered to be a viable option for the UK’s roads.

Fully AV have already been deployed in some industries such as the mining and marine industry. Driverless technology has also been implemented in some agricultural vehicles, such as tractors. AV could benefit industries that are struggling to find enough skilled workers and be used as mobile accommodation, offices and meeting rooms.
Implications for health and the workplace

- AV could make jobs in some industries such as agriculture, mining and construction much less human labour intensive by taking over highly repetitive tasks and those that expose workers to noise, inhaled air pollutants, diesel engine exhaust emissions (DEEE), carcinogens, vibration and risk of MSDs. AV could undertake many agricultural activities such as monitoring, planting, spraying and harvesting crops. AV such as bulldozers and excavators could make construction faster, cheaper and safer. Underwater AVs could take over some human diving tasks that pose very significant health risks.

- Drones could replace human workers in warehouses, reducing the risk of injury such as falls from height and risk of MSDs from repetitive tasks.

- Drones will enable access to areas that were previously dangerous or difficult to access. This may offer opportunities to reduce health risks associated with working in areas where there is the potential for exposure to hazardous chemicals and dusts, as well as safety risks such as falls from height or working in confined spaces. Drones could enable surveillance in hard-to-reach or hostile environments.

- AV could streamline the delivery of freight (platooning) and reduce the requirement for workers to drive long distances. This could reduce the risk of MSDs, fatigue and work-related stress. Drones could deliver parcels directly to customers reducing the requirements for manual handling tasks while loading and unloading goods, which could reduce the risk of injury.

- Some job roles could change and become mainly supervisory. This could result in work becoming mundane and less challenging, which could result in reduced job satisfaction and an increase in work-related stress.

- Use of AV may expose individuals and organisations to an increased risk of cyber-attack. Corrupted software could cause vehicles to behave in unexpected ways and introduce new risks, particularly in high hazard operations.
Additive manufacturing (AM)

Additive manufacturing (AM) or three dimensional (3D) printing describes the processes used to produce 3D objects using a variety of digitally-controlled machines. The technology produces items by depositing material, usually layer-by-layer, adding material where it is needed. A wide range of materials can be utilised, including polymers, metals, ceramics and bio-materials.

Recent refinements to the technology have produced various innovations including:

- Using inks that contain conductive particles, to produce wires and circuits.
- Combining several printing methods in a single print run to produce devices comprised of multiple materials.
- Using microwave energy to strengthen bonds between printed layers, which reduces fracture potential and improves durability.

AM is transitioning from the laboratory and prototypes to real-world applications. Instantaneous fault detection and correction and validation techniques produce accurate and reliable print quality. Accreditation and certification of 3D-printed parts for use within high hazard industries has been achieved. AM has successfully built large structures including bridges, pavilions, buildings and wind turbine blades.

AM is driving forward logistics, with products manufactured closer to where they will be purchased, made just-in-time and to order. This enables high degrees of flexibility and variation to match a customer’s specific needs.
Implications for health and the workplace

- AM has the potential to replace a variety of traditional skills and techniques. Processes are highly automated and require specific machinery, with less reliance on the individual, which may reduce the likelihood of workplace stress for the operator. However, the speed of technological advancement, the need for the operator to adapt to changed circumstances and removal of their traditional technical input could result in work-related stress.

- The raw materials and products of this process have the potential to cause a variety of human ill health conditions including occupational lung disease. However, if production processes are enclosed, and integrated extraction technology, if properly utilised and maintained, will control airborne exposure to hazards from raw materials. Airborne respiratory and dermal exposure risks exist due to the handling of raw materials or waste substrates. These health risks can potentially be managed, for example by the use of appropriate personal protective equipment.

- If AM technology is adopted by non-traditional manufacturers it may be used in unconventional manufacturing environments or public spaces (such as retail environments). Suitable exposure control measures may not be properly considered or applied in these circumstances, presenting potential risks to workers and members of the public.

- The technology can eliminate manual assembly tasks. However, MSDs risks due to manual handling are associated with moving bulk powder and waste material and positioning and cleaning machinery. To avoid possible health consequences, these tasks need to be correctly managed, however, some can be fully automated. MSDs risks may be greater in unconventional manufacturing environments or public spaces, particularly if undertaken by untrained personnel or without the use of manual handling aids.
The primary causes of ill health and death are changing as health care and diagnostic tools improve. Since 1998 the burden of infectious disease in more affluent societies has reduced to the point where non-communicable diseases (diseases that are not transmissible directly from one person to another) is now the leading cause of death.

Various individual factors and exposures under personal control may, in part, influence these illnesses. These so-called ‘diseases of lifestyle’ are attributed to behavioural and lifestyle factors, such as physical inactivity, unhealthy diet, tobacco intake and harmful use of alcohol. Mental health disorders may also significantly contribute to the disease burden.

As the average age of the population increases, health care bodies are tackling a modern epidemic of life-threatening diseases including diabetes, cardiovascular disease, chronic respiratory disease and cancer.

Public Health England estimates that people will be 35% less active by 2030; it also estimates that lack of physical activity, as well as reducing life expectancy, costs the UK £7.4 billion a year.

MSDs and stress, depression or anxiety are ranked as the most prevalent work-related health problems, each reported to affect over half a million workers in Great Britain in 2017/18. It is not clear how lifestyle factors, and the use of technology both at home and at work, contribute to such health problems.

Public health bodies, charities and workplace organisations are campaigning to help workers reverse the trend of unhealthy behaviours in work and at home, to be physically active every day, where or if possible, and to have longer, healthier working lives.

People having appropriate and good quality longer working lives is crucial to the future of the UK economy. Older workers bring a broad range of knowledge, skills and experience to the workplace. The Equality Act 2010 protects employees against discrimination on grounds of age and disability and other factors, and places a duty on employers to support workers with chronic or progressive illnesses. There is research interest to gather evidence about the high prevalence of MSDs among sedentary workers and what effect sedentary working will have on people’s extended working lives (see, for example, HSE’s Science and Evidence Delivery Plan 2018/2019).

Gartner – a world leading research and advisory company – proposes that wearable smart fitness devices (see page 20) may be part of the solution for workplaces to help improve worker health. They predict that by 2021, ten percent of wearables users will have changed their lifestyle, and will thereby extend their life span by an average of six months.

The Health Foundation warns that millennials could become the first generation to have worse health than their parents in middle age. This is due, in part, to uncertain employment prospects and difficulty building supportive relationships leading to long term stress. Long term stress has been shown to increase susceptibility to diseases such as diabetes, cancer, and lung and heart disease. Employer associations, working with mental health charities, hope to educate the next generation of workers from the start of their career to change mental health attitudes.

Every year 140 million working days are lost to sickness and around a fifth of these are work-related. It makes sense for employers to take health and wellbeing issues increasingly seriously, to gain both financial and wider non-financial rewards.

Human machine interfaces (HMI) are that part of the machine dealing with the exchange of information between a machine and the operator. HMI have three components – input devices, displays/output devices and an inner structure often consisting of both hardware and computer software. The operator inputs instructions and the machine relays back information once the instructions have been executed. Increasingly complex HMI systems are prevalent across all areas of work, no longer confined to manufacturing or production plants. HMI technology generally enables the worker to do more and faster.

Interfaces have progressed from keyboards and screens to incorporate hands-free interaction and have moved beyond a control panel to being immersive and wearable. The technology of virtual reality (VR) immerses the user in an artificial 3D world while augmented reality (AR) retains the real world and adds artificial, virtual elements. Mixed reality links virtual and augmented realities, placing 3D objects in a real-world context. Haptic technology harnesses sound waves and adds touch sensation and gesture control. AR has the potential to transform plant, production and control rooms by playing an increasingly important role in design, training, maintenance and repair and decommissioning.

Looking further ahead, research in the field of non-invasive brain-computer interfaces (which harness the brain’s electrical impulses to control electronic devices) may lead to the technology being used to control tools and machinery in the workplace.
Implications for health and the workplace

- HMI may lead to increasing automation of operator tasks, with the potential to remove humans from hazardous environments.

- Computer algorithms are automating a wider range of routine intellectual tasks and enabling computers to make context-based decisions; meaning that tasks and responsibilities between the operator and machine could be shared dynamically. In some cases this may lead to improved health and safety decisions but the reverse may also be true.

- As HMI technology develops and has the potential to be applied to a wider range of tasks, the operator’s role could be reduced to monotonous monitoring, which could result in increased boredom and loss of situational awareness. Operators may feel that there is reduced control over work volume and organisation, which has the potential to cause work-related stress.

- The introduction of very different HMI may also cause work-related stress for people who have to learn new ways of working. A younger generation of employees may be more familiar with experiencing immersive technology and hands-free interaction, but could lack experience at the machine interface.

- Evidence suggests that wearable HMI may present a risk factor in MSDs, for example increasing strain on neck and shoulders if not properly designed.

- HMI which is well designed and considers human physical and mental capabilities and behaviours can help reduce errors, increase efficiency and productivity, improve reliability and reduce operator demands. Deficiencies in complex HMI design have the potential to cause occupational ill health, such as MSDs and work-related stress.
Robotics and autonomous systems (RAS)

Robotics and autonomous systems (RAS) are programmable machines - often stand-alone - that can carry out complex tasks with a high degree of autonomy. The technology continues to develop into many forms to address specific applications and common features include: processing software; sensors that collect data from the immediate surroundings; the ability to move both themselves and objects; the capacity to interface and interact; and increasingly, the ability to work alongside people without conventional physical safeguards being in place.

RAS (including drones and autonomous vehicles) are expected to have a major impact on most economic sectors in the next 10 years. This is due to the increased up-take, focussed application, improved effectiveness and market competition they have the potential to deliver. Implementation and adoption of RAS brings both disruption and innovation and key to their success is the translation of this into economic growth. Currently, the manufacturing, transport, logistics, agriculture, energy and healthcare sectors are leading the way.

Recent developments have produced various innovations including:

- High precision and dexterity, with soft, flexible grips.
- Bricklaying robots that can cut and lay up to 1000 bricks per hour.
- Remote and autonomous monitoring and sensing systems.
- ‘Chat-bots’ for use in the social care and healthcare sector.
Implications for health and the workplace

- Increasingly, RAS are designed to interact with people to deliver direct benefits – such as supporting workers in performing manual tasks, by undertaking repetitive aspects or heavy lifting. Safety design features will firstly seek to avoid RAS coming into contact with people. Where this cannot be avoided, or where contact is required, to limit it to a safe level. Where RAS and people share the same workspace, the integrity of both health and safety-related control systems is of major importance.

- With their ability to monitor, sense and detect, RAS provide opportunities for remote inspection in hazardous environments. This may remove the need for work at height or at depth or to avoid exposure to radiation, heat or pressure. RAS can also monitor and control the workplace environment, providing protection from exposure to airborne hazardous substances that can cause occupational lung disease.

- Human perceptions of RAS, in respect of trust and ethics and the decisions RAS may make on our behalf, will be something that needs to be considered and addressed to enable this technology to be integrated into workplaces and deliver an autonomous future.

- The way this technology is introduced can have a significant impact on its acceptance and the necessary trust created. The design and application of RAS must take account of ethical standards and safety design features. Ethical questions have broader implications due to the associated issues of fear and stress that working with, and alongside RAS, may bring.
Multi-generational working, with four generations in the workplace, is becoming increasingly common. Fewer young people are entering the workforce, and by 2020 36% of the UK working population will be aged over 50. Some people are now delaying retirement until their 70s or 80s – perhaps due to choice or out of financial necessity. It is likely that more of these workers will have multiple health conditions.

The next generation of workers (sometimes referred to as Generation Z, born in the late 1990s) are entering a workplace where work is becoming increasingly flexible - potentially precarious and insecure for some, yet offering benefits for others. They are the first generation to be fully integrated with technology and digital communication – a ‘digitally native generation’.

There are indications that Generation Z may be less at risk – compared to previous generations – as a behavioural shift is being seen in terms of declines in youth crime, smoking, drinking and sexual activity. However, high rates of depression have been found amongst those born after Generation Z, with evidence of a link between mental ill health, technology usage, inactivity and obesity.

Those generations born after the 1980s may be more likely to be overweight or obese, potentially due to changes in social norms and environmental factors and an increase in the proportion of children failing to meet recommended levels of physical activity.
The gradual change in behaviours between different generations is being driven by the social, technological, economic and political landscape into which each generation is born (and which they are likely to be exposed to as they age and work). This is resulting in both positive and negative health outcomes. For example, changing employment practices – facilitated by technology - may bring increased flexibility for some, yet increase insecurity and mental ill health for others.

Digital tools might support people in self-management of physical and mental health. However, time spent online has been found to be associated with anxiety and depression, indicating the possibility of a future workforce increasingly at risk of work-related stress and related mental health issues.

Identifying potential health risks arising from a changing workforce is difficult, as health issues are the result of individual factors, combined with accumulated exposure to both work-related and non-work related factors. Flexible working patterns may benefit health by providing improved work-life balance. However, prevalence of stress at work may increase if individuals feel unable to psychologically detach from work-related issues due to being continuously connected - perhaps due to employer expectations.

It is possible that societal gains made in improving the health of previous generations may be eroded by the precariousness and instability of the lives some young people now face. Young people inhabit a complex world, where it may be difficult to establish the building blocks for a healthy future.
Wearables in the future working world

Smart, wearable technology includes devices with the ability to connect to the internet, incorporating sensors, that may be worn on, close to or even inside the body.

Smart wearable devices include activity/fitness trackers - worn as watches or wristbands - smart contact lenses, hearing aids and clothing. Medical-grade wearable devices such as smart skin patches and smart pills are being piloted to assist with patient-centred management of chronic diseases, such as heart disease, diabetes and lung disease (chronic obstructive pulmonary disease, for example). Smart headsets are being trialled which allow unobtrusive communication between wearer and device that cannot be heard by those nearby.

The next generation of wearables will be smaller, smarter and less intrusive to the user. Microneedle skin patches could deliver therapeutic drugs directly into the bloodstream. Devices have the potential to gather and analyse data on a wide range of health factors such as stress, fatigue, temperature, respiration, heart rate, blood pressure, activity intensity, calories burned, sleep patterns, biomarkers and exposure levels (for example, to airborne environmental hazards). Devices that monitor for ‘early warning’ symptoms, such as a smart bra insert that flags up early breast cancer symptoms, could be worn for continuous non-invasive screening.
Implications for health and the workplace

- Wearables are expected to have a significant and growing impact on the workplace over the next few years. They may be deployed to promote physical health and work efficiency, and to monitor exposure to hazardous substances and processes. In future, improved real-time monitoring may be able to identify early signs of ill health, including those caused by workplace exposures, and provide individually tailored feedback.

- By 2025 it is expected that people will become increasingly reliant on and trusting of digital health monitoring and advice dispensed by machine algorithms. This coincides with an anticipated surge in the adoption of wearables to promote health and wellbeing. Despite there being limited health research studies about wearables in the workplace, they have the potential to become next generation health and safety tools.

- Wearables can provide timely health and safety prompts to train and protect workers; they are already being used to help manage chronic diseases and these applications may logically extend to managing ill health at work. To fully exploit the positive workplace applications, device developers may need to form product development partnerships with health and safety professionals.

- An anticipated area of concern is the risk of pervasive surveillance of employees by employers. Those intending to provide workplace wearable monitoring devices will need to ensure employee personal data is protected and employment contracts and policies are updated to prevent unfair or discriminatory treatment. Open communication with employees may help employers to gain trust and confidence about why and how monitoring data will be used and the anticipated benefits to employees, including health benefits.
Blockchain and 5G

**Blockchain**
Blockchain is a relatively new technology. It has become well known as a result of its role in supporting the cryptocurrency Bitcoin. Blockchain is an example of a distributed ledger technology (DLT). It is a method of recording digital transactions in a secure manner without the need for an intermediary (such as a bank) to guarantee such transactions. These can be financial, contractual, informational, or the transfer of anything else of value.

Blockchain does not store information in a central location. Instead, all transactions are encrypted, shared and synchronised across a network of hundreds or thousands of computers, providing transparency and an audit trail. Distributing information across a network adds security by making it more difficult to tamper with. The lists of transactions are linked together and stored in blocks. When a block is completed it is added to the chain.

Until fairly recently there has been a lot of emphasis on financial uses for blockchain. However, there are increasing numbers of non-financial applications. For example, recent research has identified significant potential for engineers to use distributed ledger/blockchain technology to improve safety. Its potential to provide transparency and traceability could help to assure supply chain provenance and maintenance cycles, enabling industry to quickly identify fraud and identify when something goes wrong.

Blockchains can be used in tandem with other applications. For example, blockchain can improve the performance of cyber security systems, the internet of things and artificial intelligence.

**5G**
Increasing numbers of devices and applications with high demand for data (e.g. blockchain) will find that current 4G networks will be inadequate and that increased bandwidth will be needed. The new ‘fifth generation’ will be known as 5G and will be faster and better suited to mobile applications. Tests of 5G are underway and 6G is already being talked of.
Implications for health and the workplace

**Blockchain**
- The full implications for occupational health and safety in the workplace are still unfolding. However, a potential use could be to improve the management of data in the public sector, for example, management of confidential information.
- Blockchain could also potentially be used to demonstrate health and safety compliance.
- If embedded into procurement systems, blockchain could have the potential to provide an automatic assurance process for health and safety.

**5G**
- In order to find parts of the radio frequency spectrum with the necessary capacity, networks will have to use the millimetre wave region (30 GHz to 300 GHz). There are conflicting views on the safety of millimetre waves. Millimetre waves have relatively short range so networks will require more, closely-sited, antennae than earlier networks.
- The high speed offered by 5G networks can allow distant medical interventions, for example remote diagnosis and even remote surgery. This has the potential to transform the delivery of healthcare.