European Agency for Safety and Health at Work

POLICY BRIEF

SMART DIGITAL MONITORING SYSTEMS FOR OCCUPATIONAL SAFETY AND HEALTH: TYPES, ROLES AND OBJECTIVES

Digital OSH monitoring systems: relevance and purpose

Digital systems and technologies have advanced more rapidly than any innovation in history[1] and are changing and impacting people's lives globally. Of particular note is the emergence of technologies such as artificial intelligence (AI) and machine learning (ML); wearables, smart personal protective equipment (PPE), exoskeletons; virtual and augmented realitity (VR and AR); widespread connectivity, the Internet of things (IoT), and big data applications, amongst others. These new digital systems and technologies have entered the EU workplaces and are transforming work for both workers and employers. The emergence of these systems has an influence on the management and improvement of workers' safety and health, as well as on the nature, location and organisation of work, which can shape and impact workers' experiences in the context of the fourth industrial revolution,[2] namely the digital one.[3]

These **new digital OSH monitoring systems are becoming relatively cheaper, more reliable, smaller, customisable, interconnected and more secure.** Their uptake is encouraged not only by their rapid technological progress but also by the need to fulfil OSH obligations when resources, such as personnel or time, are scarce and the willingness to modernise the workplace to improve OSH and its monitoring.

There is **no common and general definition** of digital OSH monitoring systems at the EU level. Definitions that are available are neither widely used nor are they specific to OSH monitoring. They mostly focus on the technological core of new OSH monitoring systems.[4] Some focus solely on surveillance systems that use digital technology albeit not exclusively for OSH monitoring.[5] Defining digital OSH monitoring systems is important as it could be the first step to understanding these systems and their limitations. Consequently, the following **definition of digital OSH monitoring systems** that focuses on their relevance and purpose is put forward:

> *Digital OSH monitoring systems use digital technology to collect and analyse data in order to identify and assess risks, prevent and / or minimise harm, and promote occupational safety and health*
>
> *Source: Ecorys, 2022*

This defintion provides a concise yet comprehensive scope of the uses and purposes of digital OSH monitoring systems, which are closely linked to acquiring useful data on workplace risks, and on workers' health. Consequently, such data can be **used by employers, with the participation of workers and/or worker representatives, to promote OSH** through different measures in accordance with the so-called hierarchy of controls. Therefore, digital OSH monitoring systems can contribute to the **OSH continuous cycle of improvement**, as specified in OHSAS 18001 and the new ISO45001.[6]

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[1] See: The Impact of Digital Technologies

[2] Schwab, K. (2017). *The fourth industrial revolution*. Currency.
Min, J., Kim, Y., Lee, S., Jang, T. W., Kim, I., & Song, J. (2019). The fourth industrial revolution and its impact on occupational health and safety, worker's compensation and labor conditions. *Safety and Health at Work, 10*(4), 400-408. https://doi.org/10.1016/j.shaw.2019.09.005

[3] Schwab, K. (2017). *The fourth industrial revolution*. Currency.

[4] EU-OSHA – European Agency for Safety and Health at Work, *Monitoring technology: The 21st century pursuit of well-being?*, 2017. Available at: https://dspace.library.uu.nl/bitstream/handle/1874/369002/VandenBroek17_Workers_monitoring_and_well_being.pdf?sequence=1&isAllowed=y

[5] European Commission, Joint Research Centre, & Ball, K. (2021). *Electronic monitoring and surveillance in the workplace : Literature review and policy recommendations*. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/1cbf6cdf-1c19-11ec-b4fe-01aa75ed71a1/language-en/format-PDF

[6] Lo, C. K. Y., Pagell, M., Fan, D., Wiengarten, F., & Yeung, A. C. L. (2014). OHSAS 18001 certification and operating performance: The role of complexity and coupling. *Journal of Operations Management, 32*(5), 268-280. https://doi.org/10.1016/j.jom.2014.04.004
Fernández-Muñiz, B., Montes-Peón, J. M., & Vázquez-Ordás, C. J. (2012). Occupational risk management under the OHSAS 18001 standard: Analysis of perceptions and attitudes of certified firms. *Journal of Cleaner Production, 24*, 36-47. https://doi.org/10.1016/j.jclepro.2011.11.008

Types of digital OSH monitoring systems

For policy, research and practical purposes, it is becoming increasingly important to understand the key types of digital new OSH monitoring systems that are available. This is expected to help clarify the different concepts and dimensions of interest in relation to their potential impact on OSH, as well as the OSH opportunities, risks and challenges of these new OSH monitoring systems. While such taxonomy should be based on few characteristics, it should also be comprehensive. It also needs to be relevant to the different levels of prevention and applicable across different sectors displaying specific and/or similar risks, addressing all or specific needs of workers, including those linked to COVID-19.

There are **two key overarching approaches of digital OSH monitoring systems**. The first is a **proactive approach** that seeks to prevent harm and, more broadly, promote health. The second is a **reactive approach** that focuses on the response to accidents and emergencies. Consequently, a taxonomy of (non-exclusive) types of OSH monitoring systems are divided into these two approaches to safety and health:

- The **proactive systems** take place before an accident occurs.[7] These mainly aim at primary prevention through tools and support used on the job, and the early identification of the presence of and workers' exposure to occupational risks. They ensure routine checks and maintenance, train workers and mentor them on the job, and thus provide data for workplace adaptations and adjustments.
- The **reactive systems** help minimise the consequences of harm, once an emergency/accident has occurred, and collect accident data for the purpose of reporting and investigation. They minimise consequences of accidents/emergencies, by signalling accidents, such as leaks or falls, and locate and assist workers through the emergency. They also help report and investigate accidents (including incidents reported by labour inspectorates), and thus provide data for corrective measures.

Crucially, both types of systems need to be considered as part of a whole in the context of the OSH continuous cycle of improvement. Both proactive and reactive systems may lead to improved OSH through (preventative and corrective) measures based on the data collected and analysed.

Table 1 illustrates the main features of the proactive and reactive types.

Table 1 Types of new OSH monitoring systems

Key dimensions	Proactive	Reactive
Purpose / Use	Identifying and preventing health and safety risks Ensuring routine checks and maintenance On-the-job support and feedback Providing data for corrective measures to improve OSH	Minimising consequences of accidents/emergencies Accident reporting Accident investigation Providing data for corrective measures to improve OSH
	OSH improvement measures	
Technologies	ICT (for example, communications, laptops, smartphones); cameras (including thermal, IR,,and so on); Wearables, Smart PPE, Monitoring Exoskeletons and other sensors; WSN; RFID; IoT; VR, AR; Cobots; Drones; Microphones or other noise measurement devices	
	AI-based / Not AI-based	

[7] See: REACTIVE AND PROACTIVE SAFETY PROGRAMS

Key dimensions	Proactive	Reactive
Risks	Physical, Safety, Ergonomic, Psycho-social, Organisational, Biological, Chemical, Radiation.	
Types of tasks	Object-related Person-related Information-related	Premises (workplace and the working environment) Plant (machinery and vehicles) People (working methods, relations and behaviour) Procedures (division of tasks, demand – control balance and structure of working hours)
Data collection & Implications related to data protection	Personal (individual & aggregated), Environmental, Equipment-specific	
	Real-time / not real-time	
	Static / dynamic	
	Sensitive (personal) vs non-sensitive (data related to equipment)	
Specific needs addressed by OSH monitoring systems	Workers with specific needs (ageing workforce, workforce diversity and inclusion, lone worker, inexperienced worker)	
	COVID-19 and long COVID-19	
	Teleworking	

Source: Ecorys 2022

While some OSH monitoring systems may be specific to one type, **there are also some that carry out both functions — proactive and reactive**. These include systems that record accidents, thus supporting accident reporting and investigation, and that are also used to train workers on safe behaviours and conditions.

Looking at Table 1, it is possible to understand how **digital OSH monitoring systems can be used across different sectors, industries and types of job**. These systems are capable of collecting data on different types of risks, such as Physical, Safety, Ergonomic, Psycho-social, Organisational, Biological, Chemical, and Radiation. The risks monitored relate to the so-called 4Ps: Plant, Premises, People and Procedures.[8] These risks refer to object- (for example, ergonomic risks and lifting objects in agriculture), person- (such as ergonomic risks and lifting patients in health and social care), and information-related tasks (namely ergonomic risks for clerical and managerial job tasks)

The data collected is comprehensive. These systems can collect **individual worker data related to OSH** such as mental and physical health and wellbeing, fatigue and stress, exposure to risks (for example, radiation levels for healthcare professionals), and send warning signals to workers when safety thresholds are approached or surpassed. They can also collect data at **aggregate workforce** level, which can provide insights into exposure to risks and/or fatigue scores and help improve OSH through structural measures (for example, safety nets, shift rotation). They can measure **environmental** workplace conditions (such as dust, noise, high heat, UV radiation) and also monitor whether **equipment** (including working tools, head, ear, and foot protection) is (correctly) worn, if is working correctly or has undergone regular safety checks.

Data accuracy is improved due to the sophistication and reliability of sensors and because data is increasingly collected in real-time, both in static and dynamic ways. It is often a continuous stream that offers more than a snapshot of OSH in the workplace. In some cases, **sensitive personal data** may be collected, that may raise concerns – over data privacy, ownership, and security. However, this can be mitigated by adopting appropriate safeguards and involving workers and worker representatives in the design and implementation of the systems, and in defining their goals and objectives.

Digital OSH monitoring systems, as shown in Table 1, can help address the **needs of specific groups of workers**, such as those who work in dangerous situations and/or alone; workers who are young and/or

[8] Plant (machinery and vehicles); Premises (workplace and the working environment); People (working methods, relations and behaviour); and Procedures (division of tasks, demand–control balance and structure of working hours).

inexperienced; and can support inclusion and diversity in EU workplaces (ageing workforce, migrant workers, workers with disabilities, neurodivergent workers, and so forth). They are also adaptable to new needs, including those that have emerged because of the **COVID-19** pandemic such as frequent temperature testing, increased hygiene measures, maintaining safety distances, wearing masks, and contact tracing, among others. Digital OSH monitoring systems may also useful in coping with the ensuing increase in **telework** by performing checks remotely to verify whether home workstations are fit-for-purpose or to ensure workers' proper posture.

The role of digital technologies

M**any digital technologies** are used by new OSH monitoring systems, including: information and communications technology (ICT); cameras; wearables, smart personal protective equipment (PPE), and exoskeletons; virtual reality (VR) and augmented reality (AR); Unmanned aerial systems (UAS) or drones; Radio-Frequency Identification (RFID) and Wireless sensors networks (WSN). These systems are **often used in combination** due to the **Internet of Things (IoT)**, their interconnectedness and exchange of data over the internet. In turn, IoT provides **big data**, which can be used to improve OSH.

ICT includes mobile devices, PCs, software, and more. It can provide e-learning tutorials and platforms, as well as user-friendly online interactive risk assessment tools, such as the EU-level **OiRA**.[9] These technologies allow users to take pictures and record videos for reporting purposes and, more broadly, facilitate the exchange of data across various technologies and software platforms.

Cameras used to monitor activities, the environment, and behaviours can include basic systems that only record signals, which can be stored for future training purposes or to investigate and report an accident. They can also include intelligent systems with algorithms that interpret data.[10]

Wearables are electronic devices with sensors that are typically worn on different parts of the body, including the wrist, fingertips, ears, legs and skin. They use applications installed on devices, such as smartphones connected to the cloud.[11] Wearables can help monitor various health-related parameters, such as step count, heartbeat, ECG, sleep patterns, body mass, body temperature and even emotions. **Smart PPE**, on the other hand, combines traditional protective garments with smart parts, such as smart glasses, shoes and active protective trousers. Sensors are placed in locations that provide the best protection and/or make them more efficient and reliable.[12] **Exoskeletons** also have sensors, like wearables and smart PPE, but they are designed to augment and/or support the strength and resistance of workers.[13]

VR and **AR** are computer-generated scenarios that simulate real-world experiences and combine real-world experiences with computer-generated content,[14] respectively. AR enhances workers' interaction with the environment, for instance through the use of AR smart glasses.[15]

Unmanned aerial systems (**UAS**) or drones are capable of detecting leaks, picking up samples, and can be used for remote virtual inspections when combined with AR. They can also be used for search and rescue operations overground and underground, as well as in marine and coastal areas when mounted with thermal cameras.[16]

[9] OSHWiki, *OiRA and other online risk assessment tools in national OSH strategies and legislation*, 2021. Available at: https://oshwiki.osha.europa.eu/en/themes/oira-and-other-online-risk-assessment-tools-national-osh-strategies-and-legislation
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[14] Eurofound. (2021). *Digitisation in the workplace*. Publications Office of the European Union. https://www.eurofound.europa.eu/publications/report/2021/digitisation-in-the-workplace
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[16] Burke, C., McWhirter, P. R., Veitch-Michaelis, J., McAree, O., Pointon, H. A., Wich, S., & Longmore, S. (2019). Requirements and limitations of thermal drones for effective search and rescue in marine and coastal areas. *Drones, 3*(4), Article 78. https://doi.org/10.3390/drones3040078

RFID is a sensor technology based on electromagnetic signals. Radio signals emitted by an antenna activate the tag for data to be read and written to it.[17] RFID can be combined with smart PPE to warn of risks of collisions, forklift's danger areas, and to signal whether the toolbelt is missing a tool, among other uses.

WSN is a wireless sensor network that enables the localisation of workers wearing tags and the assessment of their movement. It can also be used to monitor the workplace remotely for risks related to proximity, speed, and potential collisions. WSNs can be combined with other technologies such as UAS or drones.[18]

Finally, **AI** is capable of leapfrogging all other technologies due to its predictive power and ability to accomplish complex goals. Consequently, AI not only prevents harm but also predicts accidents and emergencies. AI is interlinked with big data as it relies on massive amounts of data to learn, and in turn big data is difficult to analyse without the support of AI. It is important to ensure transparency regarding how AI works and the human-in-control principle is respected, with humans, rather than algorithms, making any final decision.

Conclusions

Digital OSH monitoring systems use digital technology, often in combination with other technologies, to provide data that can help prevent and/or minimise harm and promote occupational safety and health. The introduction of these systems presents significant opportunities to support OSH processes and enables employers and workers to save resources, including time and money, and reduce stress.

These systems provide comprehensive and accurate data that may not have been collected with traditional OSH monitoring systems. This data enables the identification and assessment of risks that may have been otherwise overlooked. This is particularly important considering that research based on ESENER data has shown that one of the key reasons for not conducting workplace assessments is the lack of major identified problems or already known risks.[19]

However, the importance of OSH monitoring for both employers and workers highlights the need for a clear and specific definition of new OSH monitoring systems. The definition should strike a balance between comprehensiveness and specificity, while also attempting to not become obsolete too quickly. This is particularly important in light of the rapid development of digital technologies and OSH monitoring systems.

Despite this, it is important to ensure that the workforce participates in setting the goals of the OSH monitoring systems and that the OSH monitoring systems are tailored to each workplace — that they are adapted rather than transplanted. It is also crucial to train and inform managers and workers on the correct use of these systems.

Finally, digital OSH monitoring systems, both proactive and reactive, are meant to increase workers' control over their health and work. They help empower them and reduce harm, including that from stress, and can be a good equaliser, addressing the needs of different groups of workers. However, they also present various risks and challenges in terms of physical and mental health and safety, as the report elaborates. Therefore, legal and policy frameworks regulating these areas should **keep pace** with the fast development of digital tools and the implications of their use in the workplace, to better assess the **impact of digitalisation on workers' rights, working conditions and OSH**.

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