

European Agency for Safety and Health at Work

Artificial intelligence for worker management: implications for occupational safety and health

Executive Summary

Artificial intelligence for worker management: implications for occupational safety and health

Authors: Karin Reinhold, Marina Järvis (Tallin University of Technology), Aleksandr Christenko, Vaida Jankauskaitė, Agnė Paliokaitė (Visionary Analytics), Arnold Riedmann (Kantar).

Project management: Emmanuelle Brun, Maurizio Curtarelli (EU-OSHA).

This report was commissioned by the European Agency for Safety and Health at Work (EU-OSHA). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect the views of EU-OSHA.

Neither the European Agency for Safety and Health at Work nor any person acting on behalf of the agency is responsible for the use that might be made of the following information.

© European Agency for Safety and Health at Work, 2022

Reproduction is authorised provided the source is acknowledged.

For any use or reproduction of photos or other material that is not under the copyright of the European Agency for Safety and Health at Work, permission must be sought directly from the copyright holders.

Table of Contents

Introduction.....	4
Risks for workers' health and safety	4
Opportunities for workers' health and safety.....	7
Prevention measures	10
Conclusions and recommendations	11
References	14

Introduction

Artificial intelligence (AI)-based worker management (AIWM) is an umbrella term that refers to a worker management system that gathers data, often in real time, on the workspace, workers, the work they do and the (digital) tools they use for their work, which is then fed into an AI-based model that makes automated or semi-automated decisions or provides information for decision-makers on worker management-related questions (EU-OSHA, 2019; European Commission, 2021; European Parliamentary Research Service, 2020; High-Level Expert Group on Artificial Intelligence, 2019a). It is one of the recent developments in the workplace that presents opportunities but also risks and challenges for workers' safety and health.

Building on its foresight work, in 2020 the European Agency for Safety and Health at Work (EU-OSHA) initiated a four-year research programme on digitalisation and occupational safety and health (OSH). The aim of the programme is to support evidence-based policy-making by providing deeper insights into the consequences of digitalisation on workers' health, safety and wellbeing and how these are addressed at the research, policy and practice levels, as well as by describing examples of successful practices.

Complementing the findings presented in EU-OSHA (2022), the report presents OSH risks and opportunities of AIWM approaches, gives an overview of the current uses of AIWM systems and related OSH risks, identifies gaps, limitations, needs and priorities for OSH, and formulates recommendations for the prevention of OSH risks. It also highlights the need for further research.

According to the report, AIWM can provide potential avenues for opportunities in improving workers' OSH, for example, by providing tools for better monitoring of hazards and the mental health of workers, improving workers' engagement and job satisfaction, helping to design and conduct safety training, and more. However, the findings indicate that the use of AI to manage workers also poses numerous risks to OSH, including, but not limited to, workers losing control over their jobs, increased work intensity and performance pressure, decreased social support from managers, and individualisation and dehumanisation of workers, creating an unhealthy competitive environment, a lack of transparency and a loss of power for workers and their representatives, mistrust, limited worker participation, blurring work–life balance, and more. These risks in turn might lead to numerous negative consequences for workers' physical and psychosocial wellbeing, such as musculoskeletal disorders (MSDs), cardiovascular disorders, fatigue, stress, anxiety and burnout.

The report suggests that a strong 'prevention through design' approach that integrates a human-centred approach in the design and usage of AIWM is needed. AIWM should be designed, implemented and managed in a trustworthy, transparent, empowering and understandable way, guaranteeing workers' consultation, participation and equal access to information, as well as putting humans in control and therefore ensuring that AIWM is used not to replace workers but to support them. This can be achieved through different means, including open and effective dialogue, worker training and active participation in the development, implementation, use and evaluation of such systems, increasing awareness of relevant stakeholders (for example, developers, workers, employers) on how AIWM systems might negatively affect OSH, and creating a strong ethical framework describing how AIWM should be developed, implemented and used, as well as ensuring compliance with existing legal provisions applicable to AIWM. A set of recommendations for OSH risk prevention concludes the report.

The main findings discussed in the report are summarised here below.

Risks for workers' health and safety

Intensification of work

The intensification of work is one of the most frequently reported risks related to the use of AIWM systems. To increase productivity, organisations might implement AIWM systems that direct workers to work without mini-breaks, minimise the time for certain procedures and force them to work at high speed. A common example of the intensification of work due to AIWM can be found in warehouse operations: to speed up work, AIWM is used for tracking order completion time as well as workers' movements, mistakes and breaks, in order to eliminate 'unnecessary' time lags. Such systems are also employed in white collar jobs. For example, Barclays, a bank based in the United Kingdom, uses tracking software in some of its offices to monitor the time workers spend at their desks or the length of their toilet breaks, informing the workers when their breaks are deemed by the algorithm to be too long,

which results in increased work intensity (Eurofound, 2020; European Parliamentary Research Service, 2020).

Loss of job control and autonomy

Loss of job control and autonomy are also commonly reported risks related to the use of AIWM systems in the workplace: some AIWM systems can take over the control of work (e.g. content, pace, schedule) through, for example, worker direction, and little will be left to be decided by the worker (Curchod et al., 2020; Kellogg et al., 2020; Saithibvongsa & Yu, 2018). Also, most algorithmic and AI-based systems dictate how to perform work or tasks to the worker and this can result in a loss of control over their work (Curchod et al., 2020; Kellogg et al., 2020). The loss of job control and autonomy is frequently associated with high levels of stress, and also leads to lower productivity, poor performance and increased levels of sickness absence (HSE, 2017). According to Karasek's (1979) job demands-control model, 'high-strain' jobs, where employees have high demands at work and at the same time very little control over what they do at work, have the highest negative impact on mental health. High demands and low control hinder a worker's capacity to choose the method and time frame to complete a job, yet require a high number of cognitive resources, which can lead to psychosocial ill health.

Dehumanisation of workers

Active use of AIWM systems, such as through excessive worker direction, evaluation or discipline, might also lead to dehumanising workers and, in the long run, force them to behave as machines (Carr, 2014; Danaher, 2017; EU-OSHA, 2018; Heaven, 2020), which could then lead to decreased cognitive and intellectual capacities, decrease of creative thinking, a loss of autonomy, shortness of independence of thought and so on. It is worth noting that while AIWM systems are expected to be able to inform workers and employers about risks (e.g. probability of fatigue and burnout), they might also lead to dehumanisation of workers as they might become dependent on the warning system created by AI and possibly lose their own ability to recognise hazards once something goes wrong. In turn, this might lead to ill health or work-related accidents.

'Datafication' of workers

It can also be argued that by introducing automation and AI-based technologies, organisations might start to see workers as mere objects or collections of 'objective' digital data that they produce while working (De Stefano, 2018), while at the same time removing margins of manoeuvre from workers, or even controlling their emotions. This dehumanisation can be referred to as the '*datafication*' of workers (Gal et al., 2020; Mai, 2016) – treating workers as collections of digital data. Although datafication is used for the digitisation of different aspects of work and tracking in real time, analysing and predicting workers' behaviour (Subedi & Pradhananga, 2021), the quantification of human life through data is controversial and may serve only economic purposes and can discriminate against individuals (Eubanks, 2017).

Worker discrimination and use of private and sensitive data

Discrimination is recognised as a main stress factor at work, and it is related to mental health issues. Usage of AIWM systems can also result in worker discrimination, as intrusive monitoring can involve collecting private and sensitive data (Ravid et al., 2020), which can in turn be used to make automated or semi-automated decisions about the worker. This can result in favouring certain workers and discriminating against others, for example, at the stages of hiring or appraising/promoting workers. Even though AIWM systems may offer accuracy when looking at the desired profile of candidates in a selection process, they may make assumptions on candidates based on their characteristics (for example, gender, ethnicity, nationality, age, sexual orientation, gender identity) and then make decisions resulting in some form of worker discrimination (EU-OSHA, 2018; Fernández-Martínez & Fernández, 2020), especially when AIWM systems are designed incorporating a bias.

Performance monitoring and impact on workers

AIWM can also force workers to work faster through constant monitoring, including monitoring the actions they perform and their productivity. When workers are aware that they are constantly monitored and their performance is evaluated, they may refuse to take breaks when needed and they might also neglect social interactions with other peers (EU-OSHA, 2018) in order to catch up with the schedule or follow the directions provided by the AIWM system. For example, when Disney Resorts introduced an electronic leader board with a traffic light theme that tracked the performance of laundry staff, workers

were struggling to keep up and started skipping bathroom breaks. The workers referred to the leader board as 'the electronic whip' (Lewis, 2019). Such systems that create a complete overview of one's performance that is visible to peers may also result in an unhealthy competitive environment between colleagues. In turn, this kind of pressure can lead to anxiety and low self-esteem in workers (EU-OSHA, 2018).

Worker rating systems

Performance pressure might also be exacerbated by, according to Wood and Lehdonvirta (2021), customer satisfaction rating systems that lead to customer algorithmic empowering. More specifically, AIWM can use customers' rankings to penalise workers, ignoring possible biases in the opinions of customers, and leading to insecurity among workers (Frey & Osborne, 2013; Lee et al., 2015). According to interviewed experts, these issues might be further exacerbated if there is no transparency from the managers on how workers are rated, as well as if workers are unable to contest these ratings and evaluations.

Risky and unsafe worker behaviours

If performance pressure is created by AIWM, for example, through algorithmic direction that increases the speed of work, or through evaluation algorithms that rate workers and force them to work more, this creates a tendency for risky or unsafe behaviours as workers may need to choose between following directions and being productive or staying safe and healthy. For example, workers may decide to remove the safety guard of a machine in order to complete the work procedure in a shorter amount of time or take a faster or more dangerous route to deliver goods to the consumer. Excessive control can also lead to a low safety culture as workers start to favour productivity over safety, as well as have less time to communicate with their peers and thereby transfer their OSH knowledge (EU-OSHA, 2018).

Repetitive movements, awkward postures and ergonomic issues

The push to work faster can also lead to a higher number of repetitive movements, awkward postures due to rushing, and less attention paid to a worker's body and limb position and ergonomics. The repetitive movements that involve the same muscle groups, a fast pace and high quantity of work are especially hazardous, as the worker has no time to recover in the short periods of time between the motions. In the long run, the body needs more effort to perform the task and recovery time becomes even more important. Hence, the faster the pace, the less time is available for recovery, and the higher the risk for MSDs (Descatha et al., 2020; Finneran & O'Sullivan, 2010). In addition, intense work can result in high levels of work-related stress, fatigue, exhaustion and burnout (EU-OSHA, 2018).

Worker reskilling and deskilling

In addition, according to EU-OSHA (2018), some tasks taken over by new technology may lead to situations where workers' initiative, concentration and skills are not required and jobs may lose meaning, and thus result in decreased job satisfaction. Interviewed experts also stressed the issues of reskilling and deskilling of the workforce because of AIWM, which may lead to a high level of work-related stress, increased levels of boredom and lower job satisfaction (CWA, 2017; Mishra et al., 2019). The study of an Italian Amazon warehouse reveals that algorithmic direction dispossesses workers of essential and required knowledge for performing their work tasks (Delfanti, 2019). In addition, fast technological change may require workers to learn new skills (Ra et al., 2019) and, even, may lead to skills-displacing technological change, which can be defined as 'technological change that may render workers' skills obsolete' (McGuinness et al., 2019, p. 3). Related to AIWM, this implies that some systems, such as those that direct workers, might lead to workers losing some of their skills.

Worker loneliness and social isolation

Extensive usage of AIWM by an organisation can also make workers feel lonely and isolated. This is because such systems often force workers to communicate less with their peers by forcing them to work more and focus on productivity. In turn, due to the lack of communication between workers, and a lack of social support, the environment is not encouraging for camaraderie and no close work community is formed (Bérestégui, 2021). This, in turn, may lead to fierce competition among employees and thus endanger cooperation and team spirit and the working climate more generally. These problems can increase work-related stress and, initially, may also cause workplace bullying and mobbing (O'Moore & Lynch, 2007). In turn, feelings of loneliness and isolation can lead to depression (Cacioppo et al., 2006), anxiety (EU-OSHA, 2019), and can even decrease people's capacity for reasoning and

decision-making (Murthy, 2017). Working in isolation can also decrease one's professional identity – employees lack role models or mentors and therefore cannot establish a consistent and strong professional identity (Bérestégui, 2021). In addition, Hawkley et al. (2010) showed that if the effect of loneliness accumulates, it can increase systolic blood pressure. Finally, loss of support from managers/supervisors in cases where AIWM systems replace them might lead to increased stress, anxiety and, in some cases, burnout in workers (Bérestégui, 2021). This is because supervisors play a key role in providing support to workers, as well as rewards and resource allocation (Jabagi et al., 2020), which often serves to mitigate the negative effects of high-strain jobs (Bérestégui, 2021).

Lack of transparency and trust

The lack of transparency about how AIWM systems operate is a frequently reported issue. Namely, many scholars and interviewed experts argue that worker monitoring, or usage of AIWM systems, is not usually implemented in a transparent way in organisations. Most managers and workers do not know how AIWM systems work, while some workers may not even be aware of being controlled or monitored by AI-based systems. Therefore, employees must be trained and clearly informed about the functioning of the AIWM systems and what data is collected and why, as well as be able to trust their employers to implement AIWM systems for good reasons, and this requires transparency within the organisation and proper worker consultation and participation. However, according to interviewed experts, many organisations are not truly transparent about what kind of data they collect and how it is used. This lack of transparency is reportedly related to informational asymmetries (Gregory, 2021; Rosenblat & Stark, 2016; Shapiro, 2018; Veen et al., 2020), which provide an advantage only to those who hold full information.

Power asymmetry

AIWM systems are also reported to deeply alter the industrial relations within an organisation (Aloisi & Gramano, 2019). For instance, the heavily competitive culture that AIWM systems might create through, for example, gamification can prevent workers from teaming up and can lead to the deterioration of organising and negotiating power (Eurofound, 2020). Similarly, heavy worker monitoring that allows employers to collect sensitive data on workers further shifts some power from workers to employers. The power asymmetry can trigger feelings of anxiety and vulnerability in workers (Curchod et al., 2020). A recent study by Tomprou and Lee (2022), focusing on how algorithmic management may affect the relationship between employer and employees with a focus on psychological contracts and employees' perceptions of their own and their employers' obligations, sheds some light on this. For example, the study demonstrates that the way in which employees form and evaluate their psychological contracts with an algorithmic (versus human) agent depends on inducements (e.g. relational or transactional). According to Tomprou and Lee (2022), employees perceived greater employer commitments when the human agent communicated and explained the relational inducements in recruiting (e.g. during a video-based recruiting process). In addition, regardless of the inducement type, people reported greater turnover intention when the human agents under-delivered as compared to the algorithmic agents.

Malfunctioning and consequences for workers

The aforementioned risks can be further exacerbated if AIWM malfunctions through data input or analysis problems, inaccuracies with systems and other software problems (Brione, 2020; EU-OSHA, 2019). For example, if an AIWM tool directs workers towards a hazardous situation, it can lead to severe physical harm and, in some cases, even death. This issue is especially prevalent in the manufacturing sectors and warehouse-centric work where accidents between vehicles and humans can occur. Malfunctioning AIWM systems can also have a negative psychological effect as workers might feel frustrated and/or confused when they do not get clear and sufficient responses to their questions and relevant information, for instance, on how to perform tasks, or when communication and the distribution of tasks within an organisation is organised and managed by using automatic response systems and AI-based systems (Todoli-Signes, 2021).

Opportunities for workers' health and safety

Risks monitoring

One way in which AIWM might improve OSH is through improving monitoring of the workplace, the workers and the work they do by analysing, in real time, human behaviour and work patterns. This can be used to improve OSH risks monitoring (Min et al., 2019). For example, AIWM tools that direct workers

on how to perform their tasks might also monitor their posture to identify if it is inappropriate and if it poses MSD risks (Katwala, 2017). This can be done by, for example, using a framework developed by Alwasel et al. (2017) that allows to identify whether workers are working in a productive way without jeopardising their health through unsafe poses. One expert also mentioned that such systems can be used to identify whether or not a worker who is working with dangerous equipment is concentrated on the work tasks being carried out, as mistakes due to distractions or lack of concentration could lead to injuries. Other scholars (Aliabadi et al., 2014; Ciullo et al., 2019; Iida et al., 2021) have also acknowledged the advantages of AIWM systems as a supportive tool for OSH experts and occupational health doctors, for example, by providing data and analyses for the diagnoses of work-related, or even occupational, diseases. AI can also be used to detect if a worker is wearing the right protective gear, thus reducing the risk of accidents and health disorders. For example, AIWM can detect if a worker is working at a designated height without taking adequate safety precautions (e.g. harness equipment) and warn them about this, as well as send an alarm to the control centre (Palazon et al., 2013).

Mental health monitoring and digital counselling

Enhanced monitoring through AIWM systems can also allow for workers' mental health monitoring, for example, by assessing workers' psychological distress levels, as revealed in a Japanese study (Doki et al., 2021) and in an Italian–Mexican study (Hernandez-Leal et al., 2015), or estimating the probabilities for different psychosocial issues (e.g. burnout) (Oracle and Workplace Intelligence, 2020; Zel & Kongar, 2020). For example, AIWM can be used to accurately, and in real time, identify stress in workers through their writing and speech patterns (Lu et al., 2012; Rachuri et al., 2010). AIWM can also be employed to detect burnout and exhaustion in workers and would therefore allow for prevention measures. For example, Estevez-Mujica and Quintane (2018) propose a model that, according to them, explains about 34% and 37% of the variance of burnout and exhaustion, respectively, and successfully distinguishes between workers with higher and lower risks for burnout. Additionally, AIWM systems that can listen in on workers talking and that are able to analyse this information can identify and detect cases of bullying or sexual harassment. The same can apply to AIWM that can perform speech or text (e.g. content of emails) analysis. For example, Sanchez-Medina et al. (2020) described an AI-based tool that can explore and analyse relationships between certain personality traits (e.g. psychopathy) and potential sexual cyberbullying behaviours. Another way to use AIWM for improving workers' mental health is through digital counselling. Given that the good mental health of workers, which leads to higher productivity, recently became an important goal for many organisations, some of them started to experiment with AI-based mental health chatbots (Cameron et al., 2017; Oracle and Workplace Intelligence, 2020).

Worker engagement and satisfaction

An AIWM system might also be used to promote employee engagement and satisfaction (Hughes et al., 2019). For example, AIWM systems that are less focused on heavy worker control but more on supporting workers (e.g. AI-powered worker collaboration systems that improve communication between workers and help to identify people with relevant skills who can help on a job) may facilitate engagement, as it might give more freedom to workers (Hughes et al., 2019). Gamification technologies that reward workers for their job performance might also improve engagement (Hughes et al., 2019). Similarly, AI-powered chatbots and virtual assistants that workers can use to get relevant human resources (HR) or work-related information can also help with improving worker satisfaction (Galín & Meshcheryakov, 2020; Zel & Kongar, 2020).

Personalising workstations and work routines

In addition, AI-based systems can also be used to **personalise workstations and work routines based on workers' needs** to create a better match between the worker and the work tasks, for instance, tailoring them for disabled or ageing workers (Segkouli et al., 2021; Soter Analytics, 2020). Herzog and Harih (2020) proposed an AI-based decision support system that identifies/categorises workers with disabilities and then selects the most suitable work routines or physical workplaces according to the requirements for disabled workers. Finally, personalised work planning and scheduling could also take into account workers' health (e.g. fatigue levels) in order to assign easier work to those who are overworked (Brione, 2020; Tursunbayeva, 2019).

Designing healthy and safe jobs and workplaces

By collecting data from the workplace, AIWM systems can also be of support in designing and implementing safety training programmes for workers or can be used to inform the development of the most appropriate health and safety strategies, as stated by the interviewed experts. In addition, AIWM systems can be used to better plan and design activities, tasks and workers' schedules in order to minimise risks. This can allow employers to monitor, minimise and control workers' exposure to psychosocial risks and to hazards such as chemicals, noise, vibration and others. Additionally, AIWM systems can provide individual risk-related profiles for workers based on their health surveillance on possible health risks, their current risk level, and the likelihood of future health risk by, for instance, analysing and identifying which workers are more sensitive and susceptible to specific hazards, such as noise, high/low temperatures and similar (Chamorro-Premuzic, 2020; EU-OSHA, 2018).

Impacts of AIWM on OSH based on ESENER-3 analysis

To complement the discussion on risks and opportunities that AIWM might bring to OSH, the report also provides a brief overview of the analysis of the Third European Survey of Enterprises on New and Emerging Risks (ESENER-3) data with the aim to explore the relationship between technologies enabling AIWM and the health and safety of workers. These technologies include: (i) robots that interact with workers; (ii) machines, systems or computers determining the content or pace of work; (iii) machines, systems or computers monitoring workers' performance; and (iv) wearable devices, such as smart watches, data glasses or other (embedded) sensors.

According to ESENER-3 findings, organisations that use any of the aforementioned digital technologies report different OSH risks more frequently than workplaces that do not use such technologies. For example, around 47% of the establishments that do not use any of the aforementioned technologies reported the risk of time pressure, while around 60% of organisations that use at least one of the aforementioned technologies reported that risk. Similar trends can be identified when looking at the other OSH risks, such as repetitive hand or arm movements, prolonged sitting, tiring or painful positions, poor communication or cooperation within the organisation, and long or irregular working hours, as workplaces using at least one of the aforementioned technologies report these risks more frequently than workplaces that do not use any of the technologies enabling AIWM systems.

The usage of robots that interact with workers is positively correlated with physical risks such as repetitive hand or arm movements and risk of accidents with machines or hand tools. Given that the regression model controls for different organisational and other factors, the results imply that the usage of these technologies fosters more repetitive work, which in turn might increase the risk for MSDs. The results imply also that the usage of robots is related to an intensification of work as the only two psychosocial risks that statistically significantly correlate with the usage of robots are time pressure and long or irregular working hours.

The usage of machines, systems or computers determining the content or pace of the work is statistically significant and positively correlated with tiring or painful positions and risk of accidents with vehicles in the course of work, but not on the way to and from work. This might imply that such technologies foster a fast and uncomfortable working environment that might lead to, for example, MSD problems due to tiring and painful positions, or increased risk of accidents. In addition, these digital technologies are also strongly correlated with the risks of time pressure, implying that they might increase work intensity, which might lead to OSH risks, such as an increase in the probability of accidents. It is worth mentioning that these results can also be explained by the fact that these technologies are more frequently used in manufacturing settings.

The usage of machines, systems or computers monitoring workers' performance is more common in manufacturing and as a consequence correlates with the risk of repetitive hand or arm movements and the risk of accidents with machines or hand tools. In addition, the usage of machines, systems or computers monitoring workers' performance is strongly and positively correlated with the risks of poor communication or cooperation within the organisation. This might also involve a lack of communication regarding the usage of such technologies to workers, meaning that workers might often be unaware if they are watched and for what reason. This conclusion is also supported by several interviewed experts who expressed similar concerns.

Finally, the usage of wearable devices, such as smart watches, data glasses or other (embedded) sensors correlates positively with a risk of tiring or painful positions. This implies that such tools might

be more frequently used in workplaces where workers perform work tasks in tiring positions. In addition, the usage of this technology also correlates with long or irregular working hours, which also implies that this technology might be connected to some extent to an intensification of work.

Twenty-four per cent of establishments that introduced any of the aforementioned technologies discussed the OSH implications stemming from deploying the technologies in the workplace with their employees. Workplaces that use wearable devices, such as smart watches and glasses, discuss how technologies might affect OSH more frequently (51%) than workplaces using machine systems or computers to monitor workers (38%), workplaces using robots interacting with workers (36%), and workplaces using machine systems or computers determining the consent and pace of work (34%). Discussions on the impact of these technologies on OSH are more frequent in workplaces where worker representation is in place, which is an indicator of the importance of social dialogue to prevent OSH risks related to AIWM.

Prevention measures

When introducing AIWM systems in the workplace, a precautionary principle is advised. Often, given the newness of the technology, it is impossible to predict all risks that might arise due to the use of an AIWM system. Hence, a human-centred approach should be adopted to carefully inform all the stages in designing, developing, integrating, using and assessing AIWM systems.

Effective workers/employer dialogue and workers' participation

Human-centred AIWM systems should be pursued by organisations fostering effective dialogue between workers, employers and AIWM systems developers (where relevant), and – most importantly – ensuring workers' involvement and participation in all stages of the design, development, implementation and assessment of AIWM systems in the workplace. Workers' participation is considered by most of the consulted experts the cornerstone of preventing the negative impacts of AIWM on OSH and identifying the possible opportunities that come with them. That implies that workers should be at the table when deciding on safeguarding workers' privacy and data protection, addressing surveillance, tracking and monitoring, making the purpose of AI algorithms transparent, ensuring the exercise of their right to explanations regarding decisions made by algorithms or machine learning models, and ensuring that workers' safety and health is at the forefront of the discussion. This will allow to improve transparency, fairness, data privacy, trust, accountability and OSH within an organisation when using AIWM.

Considering the implications of AIWM for OSH at the early stages

It is also important to highlight that, in general, considerations on how AIWM can affect OSH should already be taken into account at the research and design phase of such systems. The key aspect here is that it is important to understand the original purpose for which AIWM systems are being introduced in workplaces (e.g. improving productivity, efficiency, cooperation between workers) and if this can pose risks to OSH. Hence, to ensure that AIWM systems do not lead to negative OSH effects, such systems should predominantly support and protect humans, ensuring their safety, sustainability and reliability (i.e. making sure that such systems do not make mistakes that might harm workers). In other words, newly designed AI-based systems need to be integrated into work environments in such a way that all their configurations focus on the health, safety and wellbeing of workers (EU-OSHA, 2018).

Risk assessment of AIWM in all stages

According to interviewed experts, an advanced risk assessment of AIWM needs to be conducted not only when the AIWM systems are deployed in the workplace (e.g. as part of the workplace risk assessment) but also at the earlier design and development stage by developers. The assessment should focus on the full range of possible impacts in terms of OSH challenges and risks, as identified and described in this report and in EU-OSHA (2022), but also cover the opportunities and advantages offered by AIWM. In addition, given that AIWM systems are able to evolve and self-learn, a systematic approach of analysing AIWM and its effect on OSH is crucial. That is, the assessment of such systems should be carried out periodically, with the involvement of workers, to ensure that previously safe systems have not become harmful over time.

Skills and training for workers to understand and safely use AIWM systems

Some workers might lack the necessary skills and knowledge to fully understand AIWM systems and their potential risks, which limits how much they can contribute to ensuring ethical and transparent development, implementation and assessment of such systems. Because of this, experts recommend providing relevant training for workers, which should focus on providing workers with sound awareness, knowledge and understanding of how AI works and how to work alongside it, and foreseeing how AI can change employees' tasks and roles at work, as well as the impact of AI on their health and career, are also crucial (Ponce del Castillo, 2020). These educational efforts should also provide workers with the know-how on how to challenge the decisions/recommendations made/proposed by an AI, or AIWM, system. This is also highlighted by Ponce del Castillo (2020) who emphasised that purely obtaining technical skills is insufficient. In addition, upskilling and reskilling efforts, according to several interviewed experts, should not solely be focused on workers but also on trade unions, employers' confederations and developers of AI-based systems. Education efforts should also focus on helping the older generation understand these new systems, as they might go against them due to the fact that they might be generally averse to new technologies and, due to this lack of knowledge, they might also feel anxiety, low self-esteem and/or insecurity (Alcover et al., 2021). Keeping this in mind, some interviewed experts recommended that special training with a focus on OSH should be compulsory for all workers and employers (companies) who deploy and use AI-based systems.

Developing an EU-level ethical framework

Ensuring that AIWM does not lead to negative OSH effects can be fostered, as highlighted by several interviewed experts, through the development of an EU-level ethical framework for digitalisation that would dictate how AIWM, and AI-based systems in general, can be used in the workplace. More specifically, interviewed experts considered that there are ethical ways to adopt and implement AIWM systems to promote safety and health at the workplace. This is supported by several publications (e.g. Abdullah, 2019), some of which even provide proposals on what such an ethical framework could look like (e.g. High-Level Expert Group on Artificial Intelligence, 2019b).

Conclusions and recommendations

AIWM systems in the workplace can provide potential opportunities to improve OSH, as they can be used to improve workplaces' hazards monitoring or workers' mental health monitoring, representing an important chance to improve the health, safety and wellbeing of workers. The findings discussed in the report and summarised here highlight nonetheless that the use of AI to manage workers also poses numerous risks to OSH, especially in terms of psychosocial risks.

The report suggests that a strong 'prevention through design' approach that integrates a human-centred approach in the design and usage of AIWM is needed. AIWM should be designed, implemented and managed in a trustworthy, transparent, empowering and understandable way, guaranteeing workers' consultation, participation and equal access to information, as well as putting humans in control and therefore ensuring that AIWM is used not to replace workers but to support them. This can be achieved through different means, including open and effective dialogue, worker training, and active participation in the development, implementation, use and evaluation of such systems, increasing awareness of relevant stakeholders (for example, developers, workers, employers) on how AIWM systems might negatively affect OSH, and creating a strong ethical framework describing how AIWM should be developed, implemented and used, as well as ensuring compliance with existing legal provisions applicable to AIWM. In order to address the risks related to the implementation of AIWM systems in the workplace, a number of recommendations for better prevention measures and to make the most of AIWM systems in terms of OSH improvement opportunities can be formulated.

Recommendation 1: AIWM systems need to be based on a human-centred approach

AIWM systems must be designed, implemented and managed to be safe and transparent, guaranteeing workers' consultation, participation and equal access to information at all stages, and making sure that humans are in command at any time. To ensure this, close and effective dialogue between workers and employers and collaboration between researchers, developers, industry, social partners and governments on research and innovation in designing AIWM are needed and should be actively pursued.

Recommendation 2: Risk assessment must be tailored to AIWM systems

Given the novelty of AIWM, risk assessment must cover all of the work-related factors, and it should be carried out together with specialists in the programming of algorithms in order to address and consider the existence of uncertainties and ascertained risks. In this regard, it seems necessary to develop standardised technical procedures for the risk assessment of AI-based systems based on sufficient scientific endorsement. The analysis should also follow a holistic approach, in order to address the possible risks of AIWM on OSH at different levels, such as at the specific job, organisation, sector, region or country. In addition, given that AIWM systems are able to evolve and self-learn, the assessments of such systems should be carried out periodically.

Recommendation 3: Raising awareness and sharing knowledge on AIWM systems

Raising awareness and sharing knowledge on AIWM systems usage and the related implications for OSH among employers, HR departments, workers and their representatives, OSH actors including labour inspectorates and AIWM systems developers is of utmost importance. There is a clear need to provide training for managers and workers about AIWM systems, focusing on how these can affect OSH and how to prevent related risks. Upskilling and reskilling efforts should go beyond simply giving technical knowledge to workers and should focus on providing workers with sound awareness, knowledge and understanding of how AI works and how to safely work alongside it, and foreseeing how AI can change employees' tasks and roles at work, as well as the impact of AI on their health and career. Education efforts should also not solely focus on workers but also on trade unions, employers and their confederations, and developers of AI-based systems. Regarding support systems, workers should have the means to request and get support on different issues related to AIWM and its possible effects on OSH.

Recommendation 4: Developing an EU-level ethical framework

Interviewed experts also emphasised the need for the development of an EU-level ethical framework that would dictate how AIWM, and AI-based systems in general, can be used in the workplace. At the same time, many experts agree that ethical frameworks alone will not be sufficient, and compliance with existing legal provisions applicable to AIWM (such as OSH legislation, the General Data Protection Regulation, or GDPR, forthcoming Artificial Intelligence Act and anti-discrimination law) should be ensured.

A number of additional recommendations relate more directly to the research and knowledge gaps that were identified. Overall, it is worth highlighting that in order to reduce and manage risks and make the most of the opportunities for OSH stemming from AIWM systems, it is crucial to rely on robust and evidence-based research, which will allow to design and implement informed interventions at workplace level and also policy and regulations at national or even EU levels.

Recommendation 5: Conducting interdisciplinary and holistic research on AIWM and OSH

More interdisciplinary and holistic research on how AIWM might affect OSH should be undertaken. The holistic approach should include, but not be limited to, analysing how AIWM might affect OSH in general terms, how negative effects of OSH can be mitigated through a transparent and ethical design, development, implementation and analysis of AIWM systems, how to ensure that AIWM systems do not collect data on workers beyond what is needed for their functioning, how to help workers exercise their legal rights to prevent such systems from collecting unnecessary private information, how to help them challenge the recommendations and decisions made by such systems, how to mitigate the negative effects of AIWM on OSH at the development stage, and more.

Recommendation 6: Include the human-in-command approach in research on AIWM

Research should focus on identifying to what extent humans are kept in command and AIWM systems are used to support workers rather than replace them and that their deployment does not lead to OSH risks. More focused research would allow to improve existing regulations, which have many drawbacks, including not being based on social dialogue, seldom covering workers, not including a strong accountability clause of who is to blame when AIWM systems lead to harm, and more, by ensuring that workers are always kept at the centre of them, as stated by several interviewed experts and the literature (e.g. De Stefano, 2021; Ponce del Castillo, 2021).

Recommendation 7: Consider how business management models and AIWM interact

More research is needed to understand whether existing business management models are sufficient to prevent and manage the OSH risks that AIWM might bring. As the adoption of an AIWM system often requires changes to the business management model, it is not 'a given' that the interaction between the AIWM system and the existing business management model will not lead to OSH risks. Because of this, research should focus on evaluating if currently used business models are compatible with AIWM systems and if they will not lead to negative OSH effects. If research shows lack of compatibility, it is then important to develop new models that will ensure workers' health, safety and wellbeing when AIWM systems are introduced.

Recommendation 8: Pursuing knowledge sharing between researchers and AIWM developers

More knowledge sharing between researchers and developers of AIWM systems is needed. Given that AI-based systems rely heavily on programming and also often rely on big data, in order to ensure transparency, replicability and that such systems do not lead to harm, it is crucial that the developers of AIWM systems share all relevant information with the research community at large (including also the policy and OSH communities, and other relevant stakeholders). This will allow researchers to design and carry out more accurate and informed research about how such systems might affect OSH, which could be of help in designing risk assessment tools, prevention measures, policies and regulatory initiatives.

Recommendation 9: Research on AIWM systems and OSH should be carried out on a continuous basis

Analysis to determine whether AIWM systems continue to be safe should be carried out periodically. Given that AI-based systems are able to learn from the environment and evolve, it is incorrect to assume that they are stable and not changing (Dahlin, 2021). This means that research efforts on how AIWM affects OSH should not only be carried out once at the development or integration stage of AIWM systems. An evaluation/analysis should be carried out periodically to ensure that AIWM systems that were previously deemed safe are still harmless to workers.

References

- Abdullah, S. M. (2019). Artificial intelligence (AI) and its associated ethical issues. *ICR Journal*, 10(1), 124–126. <https://doi.org/10.52282/icr.v10i1.78>
- Alcover, C.-M., Guglielmi, D., Depolo, M., & Mazzetti, G. (2021). “Aging-and-tech job vulnerability”: A proposed framework on the dual impact of aging and AI, robotics, and automation among older workers. *Organizational Psychology Review*, 11(2), 175–201. <https://doi.org/10.1177%2F2041386621992105>
- Aliabadi, M., Farhadian, M., & Darvishi, E. (2014). Prediction of hearing loss among the noise-exposed workers in a steel factory using an artificial intelligence approach. *International Archives of Occupational and Environmental Health*, 88, 779–787. <https://doi.org/10.1007/s00420-014-1004-z>
- Aloisi, A., & Gramano, E. (2019). Artificial intelligence is watching you at work. Digital surveillance, employee monitoring, and regulatory issues in the EU context. *Comparative Labor Law & Policy Journal*, 41(1), 95–121. https://cllpj.law.illinois.edu/archive/vol_41/
- Alwasel, A., Sabet, A., Nahangi, M., Haas, C. T., & Abdel-Rahman, E. (2017). Identifying poses of safe and productive masons using machine learning. *Automation in Construction*, 84, 345–355. <https://doi.org/10.1016/j.autcon.2017.09.022>
- Bérestégui, P. (2021). *Exposure to psychosocial risk factors in the gig economy: A systematic review*. ETUI. <https://www.etui.org/publications/exposure-psychosocial-risk-factors-gig-economy>
- Brione, P. (2020). *My boss the algorithm: An ethical look at algorithms in the workplace*. ACAS. <https://www.acas.org.uk/my-boss-the-algorithm-an-ethical-look-at-algorithms-in-the-workplace>
- Cacioppo, J. T., Hughes, M. E., Waite, L. J., Hawkley, L. C., & Thisted, R. A. (2006). Loneliness as a specific risk factor for depressive symptoms: Cross-sectional and longitudinal analyses. *Psychology and Aging*, 21(1), 140–151. <https://doi.apa.org/doi/10.1037/0882-7974.21.1.140>
- Cameron, G., Cameron, D., Megaw, G., Bond, R., Mulvenna, M., O'Neill, S., Armour, C., & McTear, M. (2017). Towards a chatbot for digital counselling. In *Proceedings of the 31st International BCS Human Computer Interaction Conference (HCI 2017)* (pp. 1–7). BCS Learning and Development Ltd. <https://doi.org/10.14236/ewic/HCI2017.24>
- Carr, N. (2014). *The glass cage: Where automation is taking us*. The Bodley Head.
- Chamorro-Premuzic, T. (2020, August 4). *Can surveillance AI make the workplace safe?* MIT Sloan Management Review. <https://sloanreview.mit.edu/article/can-surveillance-ai-make-the-workplace-safe/>
- Ciullo, A. S., Catalano, M. G., Bicchi, A., & Ajoudani, A. (2019). A supernumerary soft robotic hand-arm system for improving worker ergonomics. In M. C. Carrozza, S. Micera, & J. L. Pons (Eds), *Wearable robotics: Challenges and trends* (pp. 520–524). Springer International Publishing.
- Curchod, C., Patriotta, G., Cohen, L., & Neysen, N. (2020). Working for an algorithm: Power asymmetries and agency in online work settings. *Administrative Science Quarterly*, 65(3), 644–676. <https://doi.org/10.1177%2F0001839219867024>
- CWA. (2017). *Occupational Safety and Health Fact Sheet #21. Occupational Stress & the Workplace*. Communications Workers of America (CWA). <https://cwa-union.org/sites/default/files/osh-fact-sheet-21-occupational-stress-and-the-workplace.pdf>
- Dahlin, E. (2021). Mind the gap! On the future of AI research. *Humanities and Social Sciences Communications*, 8(1), Article 71. <https://doi.org/10.1057/s41599-021-00750-9>
- Danaher, J. (2018). Toward an ethics of AI assistants: An initial framework. *Philosophy & Technology*, 31, 629–653. <https://doi.org/10.1007/s13347-018-0317-3>

- De Stefano, V. (2018). "Negotiating the algorithm": Automation, artificial intelligence and labour protection. EMPLOYMENT Working Paper No. 246, International Labour Organization. https://www.ilo.org/employment/Whatwedo/Publications/working-papers/WCMS_634157/lang-en/index.htm
- De Stefano, V. (2021, April 16). *The EU Proposed Regulation on AI: A threat to labour protection?* *Global Workplace Law & Policy*. <http://regulatingforglobalization.com/2021/04/16/the-eu-proposed-regulation-on-ai-a-threat-to-labour-protection/>
- Delfanti, A. (2019). Machinic dispossession and augmented despotism: Digital Work in an Amazon warehouse. *New Media & Society*, 23(1), 39–55. <https://doi.org/10.1177/1461444819891613>
- Descatha, A., Evanoff, B. A., Leclerc, A., & Roquelaure, Y. (2020). Occupational determinants of musculoskeletal disorders. In U. Bültmann, & J. Siegrist (Eds), *Handbook of disability, work and health. Handbook series in occupational health sciences* (Vol. 1) (pp. 169–188). Springer. https://doi.org/10.1007/978-3-030-24334-0_8
- Doki, S., Sasahara, S., Hori, D., Oi, Y., Takahashi, T., Shiraki, N., Ikeda, Y., Ikeda, T., Arai, Y., Muroi, K., & Matsuzaki, I. (2021). Comparison of predicted psychological distress among workers between artificial intelligence and psychiatrists: A cross-sectional study in Tsukuba Science City, Japan. *BMJ Open*, 11, Article e046265. <http://dx.doi.org/10.1136/bmjopen-2020-046265>
- Estevez-Mujica, C. P., & Quintane, E. (2018). Email communication patterns and job burnout. *PLoS ONE*, 13(3), Article e0193966. <https://doi.org/10.1371/journal.pone.0193966>
- Eubanks, V. (2017). *Automating inequality*. St Martin's Press.
- EU-OSHA – European Agency for Safety and Health at Work, *Foresight on new and emerging occupational safety and health risks associated with digitalisation by 2025*, 2018. Available at: <https://osha.europa.eu/en/publications/foresight-new-and-emerging-occupational-safety-and-health-risks-associated/view>
- EU-OSHA – European Agency for Safety and Health at Work, *OSH and the Future of Work: benefits and risks of artificial intelligence tools in workplaces*, 2019. Available at: <https://osha.europa.eu/en/publications/osh-and-future-work-benefits-and-risks-artificial-intelligence-tools-workplaces>
- EU-OSHA – European Agency for Safety and Health at Work, *Artificial intelligence for worker management: an overview*, 2022. Preprint.
- Eurofound. (2020). *Employee monitoring and surveillance: The challenges of digitalisation*. Publications Office of the European Union. <https://www.eurofound.europa.eu/en/publications/2020/employee-monitoring-and-surveillance-challenges-digitalisation>
- European Commission. (2021). *Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts*. COM/2021/206 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206>
- European Parliamentary Research Service. (2020). *Data subjects, digital surveillance, AI and the future of work*. [https://www.europarl.europa.eu/RegData/etudes/STUD/2020/656305/EPRS_STU\(2020\)656305_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2020/656305/EPRS_STU(2020)656305_EN.pdf)
- Fernández-Martínez, C., & Fernández, A. (2020). AI and recruiting software: Ethical and legal implications. *Paladyn, Journal of Behavioral Robotics*, 11(1), 199–216. <https://doi.org/10.1515/pjbr-2020-0030>
- Finneran, A., & O'Sullivan, L. (2010). Force, posture and repetition induced discomfort as a mediator in self-paced cycle time. *International Journal of Industrial Ergonomics*, 40(3), 257–266. <https://doi.org/10.1016/j.ergon.2010.01.004>
- Frey, C., & Osborne, M. A. (2013). *The future of employment: How susceptible are jobs to computerisation?* Oxford Martin School, University of Oxford. https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

- Gal, U., Blegind Jensen, T., & Stein, M. K. (2020). Breaking the vicious cycle of algorithmic management: A virtue ethics approach to people analytics. *Information and Organization*, 30(2), Article 100301. <https://doi.org/10.1016/j.infoandorg.2020.100301>
- Galín, R., & Meshcheryakov, R. (2020). Collaborative robots: Development of robotic perception system, safety issues, and integration of AI to imitate human behavior. In A. Ronzhin, & V. Shishlakov (Eds), *Proceedings of 15th International Conference on Electromechanics and Robotics "Zavalishin's Readings"* (pp. 175–185). Springer. https://doi.org/10.1007/978-981-15-5580-0_14
- Gregory, K. (2021). 'My life is more valuable than this': Understanding risk among on-demand food couriers in Edinburgh. *Work, Employment and Society*, 35(2), 316–331. <https://doi.org/10.1177%2F0950017020969593>
- Hawkley, L. C, Thisted, R. A., Masi, C. M., & Cacioppo, J. T. (2010). Loneliness predicts increased blood pressure: 5- year cross-lagged analyses in middle-aged and older adults. *Psychology and Aging*, 25(1), 132–141. <https://doi.apa.org/doi/10.1037/a0017805>
- Heaven, W. D. (2020, June 4). This startup is using AI to give workers a "productivity score". *MIT Technology Review*. <https://www.technologyreview.com/2020/06/04/1002671/startup-ai-workers-productivity-score-bias-machine-learning-business-covid/>
- Hernandez-Leal, P., Maxhuni, A., Sucar, L. E, Osmani, V., Morales, E. F., & Mayora, O. (2015). Stress modelling using transfer learning in presence of scarce data. In J. Bravo, R. Hervás, & V. Villarreal (Eds), *Ambient intelligence for health. AmlHEALTH 2015. Lecture Notes in Computer Science* (Vol. 9456) (pp. 224–236). Springer. https://doi.org/10.1007/978-3-319-26508-7_22
- Herzog, N. V., & Harih, G. (2020). Decision support system for designing and assigning ergonomic workplaces to workers with disabilities. *Ergonomics*, 63(2), 225–236. <https://doi.org/10.1080/00140139.2019.1686658>
- High-Level Expert Group on Artificial Intelligence. (2019a). *A definition of artificial intelligence: Main capabilities and scientific disciplines*. European Commission. <https://digital-strategy.ec.europa.eu/en/library/definition-artificial-intelligence-main-capabilities-and-scientific-disciplines>
- High-Level Expert Group on Artificial Intelligence. (2019b). *Ethics guidelines for trustworthy AI*. European Commission. <https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai>
- HSE. (2017). *Tackling work-related stress using the Management Standards approach. A step-by-step workbook*. Health and Safety Executive. <https://www.hse.gov.uk/pubns/wbk01.pdf>
- Hughes, C., Robert, L., Frady, K., & Arroyos, A. (2019). *Managing technology and middle- and low-skilled employees: Advances for economic regeneration* (The changing context of managing people). Emerald Publishing Limited.
- Iida, Y., Watanabe, K., Ominami, Y., Toyoguchi, T., Murayama, T., & Honda, M. (2021). Development of rapid and highly accurate method to measure concentration of fibers in atmosphere using artificial intelligence and scanning electron microscopy. *Journal of Occupational Health*, 63(1), Article e12238. <https://doi.org/10.1002%2F1348-9585.12238>
- Jabagi, N., Croteau, A. M., & Audebrand, L. (2020). Perceived organizational support in the face of algorithmic management: A conceptual model. In *Proceedings of the 53rd Hawaii International Conference on System Sciences* (pp. 4001–4010). University of Hawai'i at Mānoa. <http://hdl.handle.net/10125/64231>
- Karasek, R. A. (1979). Job demands, job decision latitude, and mental strain: Implications for job redesign. *Administrative Science Quarterly*, 24(2), 285–308. <https://doi.org/10.2307/2392498>
- Katwala, A. (2017, July 18). *Making factories safer with VR, smart clothes and robots*. Institution of Mechanical Engineers. <http://www.imeche.org/news/news-article/making-factories-safer-with-vr-smart-clothes-and-robots>

- Kellogg, K. C., Valentine, M. A., & Christin, A. (2020). Algorithms at work: The new contested terrain of control. *Academy of Management Annals*, 14(1), 366–410.
<https://doi.org/10.5465/annals.2018.0174>
- Lee, M. K., Kusbit, D., Metsky, E., & Dabbish, L. (2015). *Working with machines: The impact of algorithmic and data-driven management on human workers*. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 1603–1612). Association for Computing Machinery. <https://doi.org/10.1145/2702123.2702548>
- Lewis, N. (2019). *Be careful: Gamification at work can go very wrong*. SHRM.
<https://www.shrm.org/resourcesandtools/hr-topics/technology/pages/gamification-at-work-can-go-very-wrong.aspx>
- Lu, H., Frauendorfer, D., Rabbi, M., Mast, M. S., Chittaranjan, G. T., Campbell, A. T., Gatica-Perez, D., & Choudhury, T. (2012). StressSense: Detecting stress in unconstrained acoustic environments using smartphones. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing* (pp. 351–360). Association for Computing Machinery.
<https://doi.org/10.1145/2370216.2370270>
- Mai, J.-E. (2016). Big data privacy: The datafication of personal information. *The Information Society*, 32(3), 192–199. <https://doi.org/10.1080/01972243.2016.1153010>
- McGuinness, S., Pouliakas, K., & Redmond, P. (2019). *Skills-displacing technological change and its impact on jobs: Challenging technological alarmism? IZA Discussion Paper No. 12541*, IZA Institute of Labor Economics. <http://ftp.iza.org/dp12541.pdf>
- Min, J., Kim, Y. M., 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>
- Mishra, A. N., Cao, C., & George, J. (2019). IT-induced employment irregularities and deskilling: Impacts on temporary worker welfare. In H. Krcmar, J. Fedorowicz, W. Fong Boh, J. M. Leimeister, & S. Wattal (Eds), *Proceedings of the 40th International Conference on Information Systems*. Association for Information Systems.
https://aisel.aisnet.org/icis2019/general_topics/general_topics/26
- Murthy, V. (2017, September 26). *Work and the loneliness epidemic*. Harvard Business Review.
<https://hbr.org/2017/09/work-and-the-loneliness-epidemic>
- O'Moore, M., & Lynch, J. (2007). Leadership, working environment and workplace bullying. *International Journal of Organizational Theory & Behavior*, 10(1), 95–117.
<https://doi.org/10.1108/IJOTB-10-01-2007-B005>
- Oracle and Workplace Intelligence. (2020). *As uncertainty remains, anxiety and stress reach a tipping point at work: Artificial intelligence fills the gaps in workplace mental health support*. Oracle.
<https://www.oracle.com/a/ocom/docs/oracle-hcm-ai-at-work.pdf>
- Palazon, J. A., Gozalvez, J., Maestre, J. L., & Gisbert, J. R. (2013) Wireless solutions for improving health and safety working conditions in industrial environments. In *IEEE 15th International Conference on e-Health Networking, Applications and Services (Healthcom 2013)* (pp. 544–548). IEEE Xplore. <https://doi.org/10.1109/HealthCom.2013.6720736>
- Ponce del Castillo, A. (2020). *Labour in the age of AI: Why regulation is needed to protect workers*. Foresight Brief #08, ETUI. <https://www.etui.org/sites/default/files/ForesightBriefs2020.pdf>
- Ponce del Castillo, A. (2021). *The AI Regulation: Entering an AI regulatory winter? Why an ad hoc directive on AI in employment is required*. ETUI Research Paper - Policy Brief 2021.07.
<https://dx.doi.org/10.2139/ssrn.3873786>
- Ra, S., Shrestha, U., Khatiwada, S., Yoon, S-W., & Kwon, K. (2019). The rise of technology and impact on skills. *International Journal of Training Research*, 17(1), 26–40.
<https://doi.org/10.1080/14480220.2019.1629727>

- Rachuri, K. K., Musolesi, M., Mascolo, C., Rentfrow, P. J., Longworth, C., & Aucinas, A. (2010). *EmotionSense: A mobile phones based adaptive platform for experimental social psychology research*. In *Proceedings of the 12th ACM International Conference on Ubiquitous Computing* (pp. 281–290). Association for Computing Machinery. <https://doi.org/10.1145/1864349.1864393>
- Ravid, D. M., Tomczak, D. L., White, J. C., & Behrend, T. S. (2020). EPM 20/20: A review, framework, and research agenda for electronic performance monitoring. *Journal of Management*, 46(1), 100–126. <https://doi.org/10.1177%2F0149206319869435>
- Rosenblat, A., & Stark, L. (2016). Algorithmic labor and information asymmetries: A case study of Uber's drivers. *International Journal of Communication*, 10, 3758–3784. <https://ijoc.org/index.php/ijoc/article/view/4892/1739>
- Saithibvongsa, P., & Yu, J. E. (2018). Artificial intelligence in the computer-age threatens human beings and working conditions at workplaces. *Electronics Science Technology and Application*, 5(3). <http://dx.doi.org/10.18686/esta.v5i3.76>
- Sanchez-Medina, A. J., Galvan-Sanchez, I., & Fernandez-Monroy, M. (2020). Applying artificial intelligence to explore sexual cyberbullying behaviour. *Heliyon*, 6(1), Article e03218. <https://doi.org/10.1016%2Fj.heliyon.2020.e03218>
- Segkouli, S., Giakoumis, D., Votis, K., Triantafyllidis, A., Paliokas, I., & Tzovaras, D. (2021). Smart workplaces for older adults: Coping 'ethically' with technology pervasiveness. *Universal Access in the Information Society*. Advance Online Publication. <https://doi.org/10.1007/s10209-021-00829-9>
- Shapiro, A. (2018). Between autonomy and control: Strategies of arbitrage in the “on demand” economy. *New Media & Society*, 20(8), 2954–2971. <https://doi.org/10.1177%2F1461444817738236>
- Soter Analytics. (2020, November 4). *How AI-driven algorithms improve an individual's ergonomic safety*. <https://soteranalytics.com/soter-blog/how-ai-driven-algorithms-improve-an-individuals-ergonomic-safety/>
- Subedi, S., & Pradhananga, N. (2021). Mapping datafication in construction-worker safety research to minimize injury-related disputes. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 13(2), 1–29. <https://doi.org/10.1061/%28ASCE%29LA.1943-4170.0000464>
- Todoli-Signes, A. (2021). Making algorithms safe for workers: Occupational risks associated with work managed by artificial intelligence. *Transfer: European Review of Labour and Research*, 27(4), 433–452. <https://doi.org/10.1177%2F10242589211035040>
- Tomprou, M., & Lee, M. K. (2022). Employment relationships in algorithmic management: A psychological contract perspective. *Computers in Human Behavior*, 126, Article 106997. <https://doi.org/10.1016/j.chb.2021.106997>
- Tursunbayeva, A. (2019). Human resource technology disruptions and their implications for human resources management in healthcare organizations. *BMC Health Services Research*, 19, Article 268. <https://doi.org/10.1186/s12913-019-4068-3>
- Veen, A., Barratt, T., & Goods, C. (2020). Platform-Capital's 'App-etite' for control: A labour process analysis of food-delivery work in Australia. *Work, Employment and Society*, 34(3), 388–406. <https://doi.org/10.1177%2F0950017019836911>
- Wood, A. J., & Lehdonvirta, V. (2021). Antagonism beyond employment: How the 'subordinated agency' of labour platforms generates conflict in the remote gig economy. *Socio-Economic Review*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3820645
- Zel, S., & Kongar, E. (2020). Transforming digital employee experience with artificial intelligence. In *2020 IEEE/ITU International Conference on Artificial Intelligence for Good (AI4G)* (pp. 176–179). IEEE Xplore. <https://doi.org/10.1109/AI4G50087.2020.9311088>

The European Agency for Safety and Health at Work (EU-OSHA) contributes to making Europe a safer, healthier and more productive place to work. The Agency researches, develops, and distributes reliable, balanced, and impartial safety and health information and organises pan-European awareness raising campaigns. Set up by the European Union in 1994 and based in Bilbao, Spain, the Agency brings together representatives from the European Commission, Member State governments, employers' and workers' organisations, as well as leading experts in each of the EU Member States and beyond.

European Agency for Safety and Health at Work

Santiago de Compostela 12
48003 Bilbao, Spain

E-mail: information@osha.europa.eu

<https://osha.europa.eu>