European Agency for Safety and Health at Work

ISSN: 1831-9343

Artificial intelligence for worker management: an overview

Report

European Agency for Safety and Health at Work

Safety and health at work is everyone's concern. It's good for you. It's good for business.

Authors: Aleksandr Christenko, Vaida Jankauskaitė, Agnė Paliokaitė (Visionary Analytics), Egidius Leon van den Broek, Karin Reinhold, Marina Järvis (Tallin University of Technology)

Project management: Maurizio Curtarelli, European Agency for Safety and Health at Work (EU-OSHA)

ISBN: 978-92-9479-679-0

doi: 10.2802/76354

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.

More information on the European Union is available on the Internet (http://europa.eu).

Cataloguing data can be found on the cover of this publication.

Table of contents

List of figures and tables

[1] NACE Rev. 2 sectors: A – Agriculture, Forestry and Fishing; B – Mining and Quarrying; C – Manufacturing; D – Electricity, Gas, Steam and Air Conditioning Supply; E – Water Supply; Sewerage, Waste Management and Remediation Activities; F – Construction; G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H – Transportation and Storage; I – Accommodation and Food Service Activities; J – Information and Communication; K – Financial and Insurance Activities; L –Real Estate Activities; M – Professional, Scientific and Technical Activities; N – Administrative and Support Service Activities; O – Public Administration and Defence, Compulsory Social Security; P – Education; Q – Human Health and Social Work Activities; R – Arts, Entertainment and Recreation; S – Other Service Activities.

1 Introduction

1.1 Rationale and objectives

Based on research by the European Commission (2021), the European Parliamentary Research Services (2020a), the High-Level Expert Group on Artificial Intelligence (2019a), and EU-OSHA (2019), **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**. 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 an d Health at Work (EU-OSHA) initiated a four-year research programme on digitalisation and occupational safety and health (OSH) with the aim of supporting evidence-based policymaking 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.

This report presents findings from EU-OSHA's project on new forms of worker management through AI-based systems and OSH. The aim of the project was to identify gaps, needs and priorities for OSH and make recommendations for policy, research and practices in order to support decision-making discussed at a high-level workshop that concluded the project. A separate report (EU-OSHA, 2022a) presents an overview of the implications for OSH of the use of AI-based worker management systems.

This report covers the following objectives:

- Review, compile, define and categorise new forms of worker management with different levels of AI integration that change existing forms of work management.
- Map the current and potential future uses of AIWM.
- Review available literature describing different AIWM tools in terms of design, implementation and usage.
- Provide an overview and critical assessment of policies, strategies, initiatives, programmes, and codes of practices or guidance that are implemented or under discussion at the EU level and in EU countries that are relevant to the design, implementation and usage of new forms of worker management through AI-based systems.

1.2 Scope

This report covers the different types of AIWM systems, the reasons why organisations implement such systems, what challenges the implementation of such systems creates for workers and employers, and what the uptake is of implementing such systems, and it discusses the regulatory context revolving around them. Geographically, this report focuses on EU-27 (2020) countries with insights from the four European Free Trade Association (EFTA) countries (i.e. Iceland, Lichtenstein, Norway and Switzerland) discussed when relevant.

Specific research on digital monitoring systems to improve OSH[2], and on the algorithmic management of workers in the context of the digital platform economy (EU-OSHA, 2021a), is undertaken as part of separate projects within the scope of EU-OSHA's research programme on digitalisation and OSH. These aspects are therefore not investigated in this report but are mentioned where relevant.

1.3 Research methods

This analysis is based on four research methods: (i) literature review, (ii) in-depth expert interviews, (iii) consultation with EU-OSHA National Focal Points[3] (FOPs), and (iv) statistical data analysis. The remainder of this section describes each of these methods in depth.

---

[2] Research ongoing at the time of the writing of this report.

[3] Official EU-OSHA representatives in the EU-27 (2020) as well as European Free Trade Association (EFTA) countries. In the majority of cases, national authorities for safety and health at work serve as representatives. For more information, see: https://osha.europa.eu/en/about-eu-osha/national-focal-points/focal-points-index

Literature review

The literature review is one of the cornerstones of this research. It was carried out following a snowballing approach based on Wohlin (2014).

- **Identifying the start set of literature.** The start set of literature was identified following recommendations made by the project's Advisory Board[4], interviewed experts, EU-OSHA and the core team. The start set covered academic literature, reports, policy documents and some grey literature. The main goal was to create a diverse initial dataset that covered one or a combination of the following topics: worker management, AIWM, and OSH.
- **Screening of the documents.** After identifying relevant texts, they were evaluated by quickly skimming through them to identify which publications were pertinent to the research**.** For this purpose, we used a predefined list of keywords (see Annex V – Key words used for the literature review) to identify whether the literature provided insights on worker management, AIWM, and/or OSH. During this step we also identified additional relevant literature based on references used in the text (that is, backwards snowballing[5]).
- **Additional literature identification.** Given the newness and narrow scope of this research, the initial list of literature did not provide exhaustive insights and therefore was supplemented with an additional literature search using appropriate keywords (see Annex V – Key words used for the literature review). We identified relevant academic papers and books using Google Scholar and Microsoft Academic[6]. For reports, we screened relevant EU and other repositories such as the EU-OSHA publication repository[7], the Eurofound publication repository[8], the Organisation for Economic Co-operation and Development (OECD) publication repository[9], and similar. Finally, due to the novelty and specificity of AIWM systems, which have not yet been explored well enough in academic literature, we additionally used the Google search engine to identify additional publications and especially grey literature. As this field is still in the early phases of development, only papers published in the last five years were considered. However, documents that were used to establish a historic account/event or were used to describe specific methodologies were included in this report. In our search we aimed to focus mainly on publications that explicitly cover AIWM and its possible effects on OSH. In total, using our initial list and additional literature identification, and after filtering out some irrelevant literature, we identified 242 documents relevant for AI, AIWM, and/or OSH that were reviewed for this report. From the identified texts, approximately 80 are peer-reviewed academic papers, 20 are working papers, including conference papers, 15 are books or book chapters, 77 are documents, such as EU policies, as well as reports, evaluations, and similar published by international organisations (for example, by EU-OSHA, Eurofound, World Health Organisation) or private organisations (for example, Oracle, PwC), and 50 are from grey literature, such as news reports/articles.
- **Extracting relevant information.** After identifying relevant literature, important insights from the research were summarised in this report. To ensure robustness, insights from a specific document were corroborated with other articles, reports, policies and similar. In addition, where possible, they were also corroborated with insights from other sources such as in-depth interviews with relevant stakeholders, EU-OSHA FOPs consultations and a statistical data analysis. However, it bears mentioning that corroboration was not always possible due to the newness and the narrow scope of the research topic.

The following limitations were noted during the literature review:

---

[4] Including Dr Christina Jayne Colclough and Professor Valerio De Stefano who were members of the Advisory Board, as well as Dr Egidius Leon (Egon) van den Broek, Dr Marina Järvis and Dr Karin Reinhold, who are key team experts and members.
[5] According to Wohlin (2014, p. 3): 'using the reference list to identify new papers to include'.
[6] A free to use search engine similar to Web of Science (WoS) and Scopus, it contains more publications, including academic papers, books, working papers than both WoS and Scopus, which it gathers from journal publishing websites and Semantic Scholar (Martín-Martín et al., 2020). Quality-wise it rivals WoS and Scopus (Martín-Martín et al., 2020).
[7] See: https://osha.europa.eu/en/publications
[8] See: https://www.eurofound.europa.eu/publications
[9] See: https://www.oecd.org/publications/

- The terminology used by researchers to define AI and AIWM lacks uniformity.
- Organisations often fail to differentiate between AI and simple rule-based algorithms when describing new forms of worker management. For this reason, it is not always possible to determine the level of AI integration, or if AI is used at all in certain examples or cases described in the literature.
- AIWM is a new and emerging trend in the business world. As such, it has been primarily researched in the context of positive outcomes and effects for businesses. Research on AIWM implications on workers and/or OSH is rare, but it is important to make assumptions about risks or to provide empirical evidence.

EU-OSHA FOPs consultation

The written consultation (survey) with EU-OSHA FOPs was carried out in order to collect additional insights on policies, strategies, initiatives, programmes and codes of practice across relevant countries. The consultation was carried out from February to April 2021 via the EUSurvey tool and included FOPs from 27 EU Member States and four EFTA countries. In total, 15 FOPs returned a filled-in questionnaire (partially or in full). Because of this, the insights collected from the FOPs do not cover all countries and might not include some important national developments in the areas of AIWM and OSH. To fill in the gaps, an additional survey of national stakeholders from relevant countries was also launched. It included four broad questions on relevant national regulations, policies and similar. It was launched via the EUSurvey tool on 12 April 2021 and was run until 10 May 2021. In total, 118 stakeholders were contacted, but only two filled out the survey (one from Lithuania and one from Luxembourg). Such a poor response rate might be attributed to the fact that the survey was conducted close to the summer break when many countries were still dealing with a variety of issues brought on by the COVID-19 pandemic. The survey questions used to collect the data for the survey are provided in Annex VI – Questionnaire for written consultation with EU-OSHA's Focal Points.

In-depth expert interviews

In-depth expert interviews were used to gather more up-to-date and deeper insights into AIWM systems, the barriers and drivers of the implementation of these systems, their current uptake across European countries, and what negative OSH-related effects the implementation of such systems might bring. They were also used to gather additional insights on relevant policies, strategies, initiatives, programmes and codes of practice. In total, 22 interviews were carried out. Individuals from the following sectors/areas were interviewed: (i) academic experts in the field of AI, AIWM and OSH; (ii) representatives of relevant think tanks/advocacy groups; (iii) representatives from EU agencies and relevant international and national organisations; (iv) social community partners; and (v) A5qIWM tool developers/consultants. To ensure transparency, in this text, we specify where we use insights from the interviews, as well as how many other interviewees share the same views. However, we do not specify the names of the experts due to General Data Protection Regulation (GDPR) concerns.

Statistical data analysis

Statistical data analysis is predominantly used to analyse the uptake of AIWM-enabling technologies across relevant countries. Data from the Third European Survey of Enterprises on New and Emerging Risks (ESENER-3) and the European Company Survey (ECS-2019) are analysed. It bears mentioning that ESENER-3 also contains a significant number of questions related to OSH that are further explored in accompanying separate report. Both the ESENER-3 and ECS-2019 analyses were carried out using bivariate analytics and regression models. For more insights, see Annex III – European Survey of Enterprises on New and emerging Risks 2019 (ESENER-3) analysis and Annex IV – European Company Survey (ECS-2019) analysis.

1.4 Structure of the report

In addition to this Introduction chapter, the report contains four main chapters:

- Defining the new forms of worker management through AI-based systems – presents a discussion on worker management, AI, and how the two can be combined to create new forms of worker management. The chapter also presents a conceptual framework of AIWM, demonstrating how such tools function.

- Mapping of current and potential future uses of AIWM – provides a description of the uptake of AIWM tools, which includes a discussion of the drivers for organisations to implement such approaches and of the challenges related to the implementation of such tools that might lead to negative OSH-related effects, as well as an overview of who uses such tools. This chapter also discusses how the COVID-19 pandemic impacted the implementation of AIWM and what the future holds for such tools.
- Regulatory contexts and their relevance to AIWM and OSH – presents an overview of regulations, policies, strategies and initiatives at the EU and national levels that are relevant to AIWM and OSH. This chapter ends with a discussion on current gaps, needs, and limitations of the existing regulations, policies, strategies and initiatives.
- Conclusions – summarises and concludes the entire report.

2 Defining the new forms of worker management through AI-based systems

This chapter presents a discussion on worker management, AI, and how the two connect to create AIWM. This chapter is structured as follows:

- A short history of worker management – discusses worker management to set the scene and scope for this project.
- Defining AI and related concepts – provides a general overview on AI and explains the main concepts that will be used throughout the research.
- AIWM: an overview and classification – connects AI with worker management and describes how new forms of worker management can be grouped and used.

2.1 A short history of worker management

According to Richman (2015) and Koontz and O'Donnell (1955), worker management refers to a process of overseeing and governing employees to better achieve organisational goals, such as increasing productivity and efficiency, decreasing employee turnover, and ensuring workers' health and safety. It is a process of worker organisation that might include, but not be limited to, worker monitoring, surveillance, control, reward and punishment systems. The roots of modern systematic worker management, where workers started to be managed following guidelines or plans instead of *ad hoc*, could be traced to the late 18th century with the Industrial Revolution and the labour movement from agriculture to manufacturing (Deadrick, 2014). During this period and the early 19th century, worker management was predominantly autocratic in nature, meaning that the high productivity among workers was predominantly created by instilling the fear of losing a job and sometimes physical violence (Deadrick, 2014; Slichter, 1919). At the time, worker safety and health were of little concern. This changed in the late 19th century with the growth of labour management disputes and unionisation forcing many managers to move to less draconian practices, such as introducing reward systems and opting out of physical punishments (Dulebohn et al., 1995 cited in Deadrick, 2014, pp. 193-194). These shifts also fostered an interest in more robust management approaches (Pindur, 1995).

To meet this new demand in the late 19th and early 20th century, many science-based methods were created. One of the most widely used at that time was created by Frederick W. Taylor who rationalised work through scientific analysis that allowed one to define what constitutes 'a good day's work' for employees (Deadrick, 2014; Pindur, 1995). Taylor was also a strong proponent of the heavy supervision of workers to ensure that they were not making mistakes (Deadrick, 2014). But it was not the only approach that appeared at that time, as around the same period Henri Fayol also developed his theory of management known as Fayolism, which implied strict worker monitoring and controlling (Ball, 2010; Pryor & Taneja, 2010). The main difference between the two approaches is that Taylor's approach looks at worker management from the bottom up, starting from the workers, while Fayol's is from the top down, starting from the company and what is important to it (George, 1968). In addition to these, other approaches also appeared at that time, including bureaucratic management by Max Weber (Serpa & Ferreira, 2019), a human relations management theory by Elton Mayo (Bruce & Nyland, 2011), and similar.

After the Second World War, when mathematical and statistical models used by the military for staff management were adapted, worker management started to use quantitative data and data analytics (Pindur, 1995). The quantitative approach was predominantly used to solve data-based problems, such as scheduling and resource allocation (Robbins & Coulter, 2018). Initially, this approach was not too widely used, but around the 1960s with the spread of computers in organisations, the quantitative approach and similar data-driven methods started to gain traction throughout (Cascio & Montealegre, 2016).

Computers, and digitalisation in general, also allowed companies to control, govern, supervise and monitor their employees to a greater extent and more intensively, capturing behaviour in detail, generating rich and permanent records always accessible to managers (Ajunwa et al., 2017; McIver, 2018; Montealegre & Cascio, 2017). These technological advancements promoted the shift of work into cyberspace (Holland et al., 2015), resulting in the emergence of new forms of work – teleworking, remote working, platform or gig works, and other smart working arrangements. More and more people were able to work in spaces other than traditional physical workplaces, such as offices, factories and stores (Mateescu & Nguyen, 2019). Such advances also allowed companies to recruit a global workforce and increase their productivity levels (McIntosh, 2018). These new forms of work, as well as rapid advancements in digitalisation, paved the road for new ways to manage workers in the 21st century. One such new way that is gaining rapid popularity involved introducing algorithms and AI elements into worker management activities (Jordan & Mitchell, 2015; Montealegre & Cascio, 2017).

2.2 Defining AI and related concepts

Nowadays, even though the concept of AI is heavily used (and misused) by many scholars, businesspeople, journalists, and companies there is no singular and widely accepted definition of AI (De Mauro, 2015; OECD, 2019; Wang, 2019). Some define it in broad terms as a tool that tries to mimic human intelligence (Fjelland, 2020). Others go down a more technical route such as the European Commission's High-Level Expert Group on Artificial Intelligence (2019a, p. 6) that defines AI as:

> *'…software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal.'*

Building on this, in its proposal for harmonised rules on AI (Artificial Intelligence Act), the European Commission (2021) proposed a definition that 'aims to be as technology neutral and future proof as possible' (p. 12). According to the proposal (European Commission, 2021, p. 39):

> *'…artificial intelligence system" (AI system) means software that is developed with one or more of the techniques and approaches listed in Annex I [of the proposal] and can, for a given set of human-defined objectives, generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with'.*

Relevant technologies and approaches include, but are not limited to, machine learning, logic- and knowledge-based approaches, and some statistical approaches (European Commission, 2021). For more, see Annex I of the proposal on AI regulation (European Commission, 2021).

In broad strokes, for AI to work it requires three elements according to the OECD (2019, p. 22-24): (i) data, (ii) algorithm(s), and (iii) hardware.

i. **Data** refers to information on which an AI tool could act on that are often collected from the environment. The data relevant for this project can be collected both by machines (for example, through machine sensors) and a human (for example, through employee interviews), and they can be in a structured (for example, tabular/table form) or unstructured (for example, textual data) form.

ii. An **algorithm**, or AI operation logic, refers to an explicitly defined set of instructions describing how a computer could perform an action, task and procedure or solve a problem using the collected data (Dourish, 2016). Regarding AI systems, they often create the appropriate algorithms through self-learning. In other words, AI uses complex mathematics to derive appropriate algorithms that can give meaning to data or use them to make decisions, predictions and recommendations.

iii. **Hardware** refers to a machine that can collect data, analyse these data and act on them through some form of actuators that perform an action based on the data.

It must be noted that even though the three elements are part of AI, not every system that has them can be considered AI-based, as many simpler systems (that is, without any 'intelligence') also use data, algorithms and hardware. This confusion is further exacerbated as some simpler systems that can be called *simple algorithms* can adapt to the environment without any AI integration. For example, a modern thermostat often has simple algorithms that can adapt its heating intensity based on the weather outside (Huang et al., 2020). Even though no strong argument can be made that a thermostat, or a similar tool, is 'intelligent', it is clear that it has adaptability capabilities. Hence, to differentiate between intelligence and adaptability, and between AI and simple algorithmic systems in turn, the '**intelligence**' in AI can be defined, following Wang (2019) and an interviewed expert on AI, as "the capacity of an information-processing system to adapt to its environment *while operating with incomplete knowledge* *and resources"*. Here, the most important part of the definition is *'incomplete knowledge and resources'*. Intelligent systems do not know the proper approach that would lead to a correct answer beforehand and do not have sufficient resources (for example, computational power, enough data, time) to derive the correct answer (Wang, 2019). That is, intelligent systems adapt by providing the best possible *approximation of a correct answer* rather than the *'correct' answer,* which is what a simple algorithm would do. Hence, going back to the example, a thermostat is not intelligent but is a simple algorithm as it contains explicitly programmed code that indicates what is a *'correct'*, or more specifically, appropriate reaction to the changing environment (for example, by how much the temperature in the building should be decreased if the outside temperature increases by a particular value). This is also heavily related with the notions of *deterministic* and *non-deterministic* AI, where the former will always produce the same output given the same input, while the latter might produce different outputs based on changing environments, for example (Cormen et al., 2009).

In broad strokes, AI comes in two types, symbolic and sub-symbolic AI:

- **Symbolic AI** refers to systems in which intelligence is explicitly programmed through the use of 'symbols' – human-understandable and computer programmable logic and knowledge (Garcez & Lamb, 2020; Lima et al., 2019; Santoro et al., 2021). These models are based on an assumption that it is possible to describe the complexity of the world and the factors in it by using a formal language that computers can understand (Lima et al., 2019). Hence, these models 'learn' only with heavy human supervision and through human intervention.
- **Sub-symbolic AI** refers to approaches that 'figure out' how to achieve a particular output with a given input on their own (Ilkou & Koutraki, 2020). Such systems can achieve this by self-learning from available data often without the need for human intervention beyond programming the initial model (Goodfellow et al., 2017; Sharma et al., 2021). Currently popular and widely discussed machine learning – an approach dealing with how computers can learn, grow and improve on their own from data without human intervention – and deep learning – a branch of machine learning that uses (artificial) neural networks to mimic a human brain – approaches are sub-symbolic (Sharma et al., 2021).

To some extent, symbolic and sub-symbolic are also related to deterministic and non-deterministic AI. Namely, AI created using the symbolic approach is often deterministic in nature, while AI systems based on a sub-symbolic approach are non-deterministic. Hence, in general, it can be stated that the usage of symbolic AI, which was prevalent several decades ago, reflects the popularity of using simple algorithms that produce deterministic results, while the relatively new trends of using sub-symbolic AI also reflect the growing use of non-deterministic approaches (Fjelland, 2020; Russell & Norvig, 2020). The higher prominence of relatively simple algorithmic management several decades ago and the growing popularity of AIWM in the past decade also reflect this trend. For an in-depth discussion on algorithmic and AIWM, see the section on AIWM: an overview and classification.

The discussion on what is AI-based can also be expanded by discussing how such systems operate. For example, Russell and Norvig (2020) separate AI into five categories. First, problem solving – an approach that finds a solution to a problem or reaches a particular goal by trying different combinations of predefined actions. Second, knowledge, reasoning and planning – logic-based systems that use knowledge representation – some information about the problem at hand – and reasoning – an approach that tries to find logic/patterns in the data – to reach a set goal. It differs from problem solving as it does not find a solution through trial and error (that is, the simulation of different actions and their effects) but is based on reasoning (that is, analysis and interpretation of available data to derive optimal steps to reach a goal). Third, uncertain knowledge and reasoning – this is like the previous approach, but here reasoning is performed under uncertain conditions whereas the reasoning model expresses a relationship between different factors not in absolutes but in terms of probabilities. For example, instead of stating that the bad posture of a worker leads to back pain, these models use probabilities indicating how likely bad posture is to affect the physical condition of a worker. Fourth, machine learning – approaches that can learn from data that include previously mentioned machine learning and deep learning. Fifth, communicating, perceiving and acting – going beyond solving specific problems to trying to replicate humans by learning to understand language (that is, natural language processing), gaining insight into and an understanding of what is seen (computer vision), and gaining the ability to move (robotics).

Another way to look at AI is based on what kind of output it creates. For example, the Robert-Sauvé Research Institute in Occupational Health and Safety (originally in French: *Institut de recherche Robert-Sauvé en santé et en sécurité du travail*) report by Comeau (2021) groups AI into three categories:

- First, **perception** – AI methods used to collect data, for example, through sensors or computer vision – an approach that allows computers to interpret images and videos. This excludes data collection methods that are not based on AI or simple algorithms (for example, video surveillance that is manned by a human).
- Second, **comprehension** – AI methods that give meaning to data by providing diagnostics – using data to explain why something did or did not happen – or **prediction** – forecasting what might happen in the future. To clarify, forecasting here refers to predictions or an estimation of the future, including estimating the probability of some event occurring, such as an individual leaving a job.
- Third, **decision** – AI-based approaches that provide solutions to problems by suggesting appropriate courses of action or performing these actions automatically. Robot systems that can collect, interpret and make decisions based on some data also fall under this grouping. Perception-based AI tools answer the question of 'what is happening', comprehension-based tools answer the question as to 'why something is happening', while decision-based tools answer the question of 'how to deal with the identified problem/issues'.

2.3 AIWM: an overview and classification

AIWM refers to a worker management system that gathers data, often in real time, from the workspace, workers and the work they do, which is then fed into an AI-based system that makes automated or semi-automated decisions, or provides information for decision-makers (for example, human resources (HR) managers, employers and sometimes workers), on worker management-related questions (European Commission, 2021; European Parliamentary Research Services, 2020a; High-Level Expert Group on Artificial Intelligence, 2019a; EU-OSHA, 2019). These decisions and recommendations might include but are in no way limited to establishing work shifts and/or the allocation of tasks, evaluating the performance of workers, monitoring the activities of workers and giving recommendations on how to prevent health risks. With AIWM systems, organisations typically aim to automate some of their activities and to improve worker performance and engagement (EU-OSHA, 2019; PwC, 2017), the organisation of work and task distribution, HR management (Lane and Saint-Martin, 2021), and workers' health and safety and overall wellbeing (Badri et al., 2018). AIWM is an umbrella term that include also algorithmic management, which is equally characterised by the use of algorithms to allocate, monitor and evaluate work tasks and/or to monitor and evaluate workers' behaviour and performance through digital technologies and the (semi-) automatic implementation of decisions (Bérastégui, 2021; EU-OSHA, 2017; Kellogg et al., 2020; Mateescu & Nguyen, 2019).

AIWM follows a sequence of events in order to arrive at a prediction, recommendation or decision. Based on OECD (2019), Russell and Norvig (2020), Tamers et al. (2020) and the project/research team's considerations:

- Data is collected on workers, their workplace, and/or the work they do using worker monitoring or worker surveillance[10].
- Data is processed so that an AI or algorithm-based system could use it. Processing might include, but is not limited to, extracting key points from textual information, structuring the collected data in a tabular form and calculating some statistics that will be used by the AI model.
- The processed data is then fed into an AI or algorithm-based system that provides output in the form of a prediction, recommendation or decision on worker management questions.
- This output is then sent to actors – humans or machines – that act upon it changing or modifying the work (for example, how tasks are performed), the workplace/workspace (for example, how

[10] Worker monitoring is the practice of capturing information on workers during working hours (Eurofound, 2020; EU-OSHA, 2017), for example, tracking the location of workers, their wellbeing, and their current task, making sure no workers are violating company policies, identifying health issues or safety risks, and so on. Worker surveillance is more intrusive worker tracking extending beyond work, including such activities as tracking social media posts and different websites visited (Edwards et al., 2019; McNall & Stanton, 2011, cited in Eurofound, 2020b).

work is organised), and/or workforce/workers (for example, how workers are disciplined or rewarded).

It is also worth mentioning that, when it comes to **monitoring based on AI**, it is different from standard monitoring approaches, according to one interviewed expert, in four main ways. First, the systems are hard to avoid as they get embedded into work processes and devices – from facial recognition to handheld devices, wearables, and sensors across the workspace to the tracking of online activity. Second, they are comprehensive – they collect large amounts of data from potentially multiple sources, including monitoring workers at the workplace and beyond it by, for example, analysing their social media posts. Third, they are instantaneous – the real-time data collected get immediately analysed. Finally, they are interactive, offering real-time communication and feedback capabilities, which can be abused by employers.

Mechanisms of AIWM

Worker management, in general, includes worker control and worker support mechanisms. It is important to note that control and support are not mutually exclusive as many organisations often employ both to manage workers. On the one hand, based on Kellogg et al. (2020), algorithmic management (and by extension AIWM) – similarly to any worker management system not based on the use of AI - consists of three worker control mechanisms – direction, evaluation and discipline – that can be split into 6 sub-mechanisms, the so-called '*6Rs'* model, which can be automated or semi-automated:

- **Direction** – 'specifying what needs to be performed, in what order and time period, and with different degrees of accuracy' (Kellogg et al., 2020, p. 372). Worker direction is implemented through **recommendations** – suggesting to workers courses of action in different situations – and **restrictions** – only sharing specific information with workers or restricting some behaviour.
- **Evaluation** – 'entails the review of workers to correct mistakes, assess performance, and identify those who are not performing adequately' (Kellogg et al., 2020, p. 369). Evaluation includes worker **recording** – monitoring/surveying workers' performance, wellbeing, safety – and **rating** – evaluating workers' performance, as well as predicting their future performance.
- **Discipline** – 'entails the punishment and reward of workers so as to elicit cooperation and enforce compliance with the employer's direction of the labour process' (Kellogg et al., 2020, p. 369). This includes **replacement** – replacing underperforming employees – or **rewarding** – rewarding high-performing workers.

On the other hand, worker management, and in turn AIWM, also includes a variety of support mechanisms (Browne, 2017). For example, this might include supporting workers to perform their task more efficiently through improved communication and cooperation between workers (Publicis Groupe, 2018). It also includes approaches aimed at preventing conflict, bullying and favouritism in the workplace through, for example, emotional distress identification tools, which in turn might increase worker engagement and, hence, productivity (Belton, 2019).

Decision-making in AIWM

From a technical point of view, AIWM can be used for semi- or fully automated decision-making.

Semi-automated means that the tools and systems do not make any decisions on their own, but they provide insights and empower human actors (for example, the HR manager) to make them.

Automated decision-making means that computers and machines make decisions on their own without the need for human supervision. It bears mentioning that even though fully automated decision-making is technically possible, at the EU level, according to Article 22 of the GDPR: 'The data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her'[11].

The level of automation in the decision-making process plays an important role in terms of impact on OSH. For example, according to interviews with experts, workers would prefer it if they were involved in the design, development and evaluation of AIWM, as well as have a say on how outputs from the AI

[11] See: https://gdpr-info.eu/art-22-gdpr/

systems are used. Such involvement of workers would help to mitigate the possible negative consequences AIWM systems might bring to OSH, and it could also serve as a 'safety net' that ensures that workers are not treated by such systems as collections of objective data points but are treated as human beings.

3 Mapping of current and potential future uses of AIWM

3.1 Uptake of AIWM tools

The uptake of AIWM is described in three subsections:

- Goals of implementation of AIWM – provides insights on the motivation behind why companies might choose to use AIWM instead of more classic worker management tools.
- Barriers and risks – provide an overview of the barriers and challenges organisations face when implementing AIWM tools, and what risks for workers and OSH issues they can create. This subsection only tentatively explores OSH-related issues as these are discussed in-depth in a separate report (see EU-OSHA, 2022a).
- Who uses AIWM tools – explores trends in the implementation of AIWM tools in the EU-27 (2020), as well as provides insights on its implementation in different EU countries, economic sectors, types of companies and more.

Goals of implementation of AIWM systems and their applications

Organisations choose their own ways of managing workers, ranging from autocratic command and control approaches (De Stefano, 2020; Kellogg et al., 2020) to more consensus, engagement and trust-building methods (Albrecht et al., 2021; Truss et al., 2013). These choices are shaped by institutional factors, such as the role of trade unions, the tradition of collective bargaining, labour market norms, cultural aspects, and by internal factors such as the size, business sector, work organisation model, available resources, management approach and similar. However, irrespective of the conditions, in most cases, the motivation to integrate some particular worker management approaches or tools is driven by a need to reach specific business objectives.

Business objectives can take many forms, however, in the majority of cases they are related to bringing economic and operational value to organisations (Kellogg et al., 2020; Mateescu & Nguyen, 2019; PEGA, 2020). Organisations achieve these objectives through modifications in how they do business and how they manage workers, which could include implementing algorithmic or AI-based systems, including AIWM. Expanding on this, a recent global survey by PEGA (2020) of over 3,000 senior managers and frontline IT employees revealed that the main reasons behind the deployment of AI technologies in workplaces are to achieve higher-quality work (65%), create more reliable work (50%), increase employee satisfaction (49%), save costs (46%) and generate revenue (43%). Similarly, a survey of 1,463 Norwegian employers (Bråten, 2017) revealed that the most common reasons why monitoring systems were deployed in workplaces were to comply with regulations and ensure the better organisation of work, as well as to improve the safety of employees or for reasons related to customers. Some academics also stipulate that AIWM tools can help employees be more efficient and effective by, for instance, improving their engagement (Hughes et al., 2019). Kellogg et al. (2020) also mention that algorithmic technologies are often implemented to improve decision-making by increasing their accuracy.

Given this, the approaches through which organisations seek to reach business objectives through the implementation of AIWM can be grouped into three broad categories relevant for the research at hand, which are explored in detail in the remainder of this subsection:

- Increasing efficiency and/or productivity – integrating changes in the organisation that include, but are not limited to, managing organisational costs, automating tasks and improving task management (Bråten, 2017; Eurofound, 2020a, 2020b; Heaven, 2020; Kellogg et al., 2020; Mateescu & Nguyen, 2019; PEGA, 2020).
- Improving the decision-making process – integrating sophisticated and robust data-driven decision-making (Deobald et al., 2019; Gal et al., 2020; Jarrahi, 2018; Kellogg et al., 2020; Raghavan et al., 2020).
- Improving worker health, safety and overall wellbeing – diminishing the negative physical and psychosocial effects of day-to-day work activities (Ajana, 2020; Badri, 2018; Belton, 2019; EU-OSHA, 2019). This may be motivated by an organisation's understanding that healthy and happy workers are more productive (Browne, 2017), which is key to an organisation's productivity and efficiency, besides (or rather than) altruistic considerations. Indeed, according

to Zwetsloot (2014), improving workers' safety and health is often driven by a need to comply with regulations, diminish the number of accidents and their liabilities in cases of one, and to reduce the likelihood of inspections, apart from other things.

Increasing efficiency and/or productivity

One way that AIWM can help reduce costs is through **automated scheduling and task allocation**. This can be considered as a type of algorithmic direction where workers are provided with instructions on what they have to do (Kellogg et al., 2020). The direction can also take the form of restricted information, for example, where workers might not receive information on specific open shifts if the algorithm deems for some reasons that a specific person is not appropriate for the shift, leading to favouritism (Kellogg et al., 2020). Such tools might allocate shifts employing different approaches, like predicting labour demand (for example, by forecasting customer demand based on weather forecasts) and scheduling workers accordingly (Kronos, 2018). A personal digital assistant, or PDA[12], can also provide information to workers about their schedule and tasks, guidance or help with their work, and propose tailored training initiatives for each worker (Afshar et al., 2021; PwC, 2019; Sheerman et al., 2020). Some virtual digital assistants can indeed listen in on management meetings, interpret what is being said regarding tasks and assign work to workers considered appropriate (PwC, 2019). Such an approach benefits companies by saving on costs, but also might benefit workers by giving them advance notice and enabling an easier and more flexible process of changing their shifts, potentially increasing the control they have over their working hours (Brione, 2020). More specifically, AI-based tools can allow workers to change their shifts without needing to directly contact human managers and/or to find willing colleagues to take their places. Such approaches might also reduce the personal bias of managers who might give worse shifts to particular employees (O'Connor, 2016).

Organisations may also seek to increase productivity and efficiency through **gamification** (Eurofound, 2020a; Heaven, 2020). Gamification refers to bringing ideas and concepts from games, such as rewards for milestones, into the work environment to improve efficiency and productivity (Savignac, 2019). It can promote collaboration and interaction between teams, reduce stress and improve overall employee satisfaction in the workplace (Makanawala et al., 2013). Though gamification does not require AI to operate, it can enhance it by proposing personalised rewards and penalties for workers (Rallyware, 2017). According to Kellogg et al. (2020), gamification is a type of worker discipline as it involves rewards.

Gamification is heavily used in platform work, such as in ride-sharing apps (for example, Uber), lodging sharing (for example, Airbnb), online marketplaces of freelancers (for example, fiverr), and similar. In recent years, it also started to gain popularity in more traditional forms of work (Shpakova et al., 2017). For example, according to Kellogg et al. (2020):

> *'Nike, Google, Microsoft, Deloitte, Amazon, Samsung, Target, Disney, and many other large corporations have embedded the methods of game design in their day-to-day business processes …. They have relied on smartphone-based apps, scoreboards, and video/app game elements such as digital points and badges to promote the structure, look, and feel of a designed game with the intent of advancing employer goals.' (p. 384)*

Furthermore, AIWM systems can be used to increase efficiency and productivity **by providing direction and guidance to workers** (Eurofound, 2020b; European Parliamentary Research Service, 2020a; Kellogg et al., 2020; Wujciak, 2019). It involves both providing recommendations, often in real time, as to what a worker should do and restricting them from unwelcome actions (Kellogg et al., 2020). It differs from automatic scheduling and task allocation as it goes beyond simple scheduling to also provide instructions and guidance on how to perform specific tasks. For example, Amazon has experimented with ultrasonic employee wristbands that emit ultrasonic sound pulses and radio transmission, tracking the hand placement of employees as they retrieve items, and steering them in the right direction of where they need to bring them by using vibrations (Wujciak, 2019). However, this does not mean that the tool forces the user to move in a particular direction, as, for example, the wristband can simply provide a LED arrow indicating the appropriate direction, which changes direction depending on where the wearer actually moves (Brady, 2016). Barclays, a United Kingdom-based bank, in some of its offices uses tracking software that monitors the time workers spend at their desks or the

[12] See: https://en.wikipedia.org/wiki/Personal_digital_assistant

length of their toilet breaks and gives suggestions on how to reduce non-productive time if they fall behind their targets (Eurofound, 2020b; European Parliamentary Research Service, 2020a). According to an interview with the representative of a national institute for the prevention of occupational accidents and diseases, as well as Brione (2020) and Roose (2019), some call centres also use an AI-based tool such as Cogito, which not only logs hours or records activity but also tells workers exactly what to do in real time.

In addition, AIWM helps companies to **manage, and reduce, costs**. These systems indeed help to save on labour costs by automating (some of) the tasks of human managers, as well as routine tasks of HR managers, allowing them to spend more time on high-value-added activities (Zel & Kongar, 2020). For example, virtual digital assistants[13], or chatbots, help employers with worker management and can provide workers with relevant information, for example, on vacation days and benefits, with help with the onboarding of workers, answering critical questions on demand (Zel & Kongar, 2020). Also, it is important to note that though such systems are not used too extensively today, according to Bradley (2020, p. 1), 'by 2025, 50% of knowledge workers will use a virtual assistant on a daily basis, up from 2% in 2019.'

However, AIWM systems can also lead to a variety of risks for a worker's wellbeing, safety and health. For more insights on risks and challenges that AIWM might create for OSH, see the Barriers and risks subsection and EU-OSHA (2022a), while for more tools and a short description on how they might affect OSH see Annex II – Examples of new forms of AI-based worker management.

Improving the decision-making process

Implementing an AIWM system may provide sophisticated insights allowing for, presumably, a more accurate and robust decision-making process (Deobald et al., 2019; Jarrahi, 2018). This, presumably, will also lead to higher productivity and efficiency in an organisation. AI may allow for the improvement of the decision-making process as compared to more classic decision-making; it can analyse very granular data at rapid speeds to give insights, recommendations and decisions in real time (Phillips-Wren, 2012). However, the use of AI also brings with it many caveats. For example, AI can exacerbate the bias of individuals who created the tool who intentionally or not have injected their beliefs into it (Benjamin, 2020; Deobald et al., 2019; Noble, 2018). In addition, according to many interviewed experts, such AI-based decision-making tools that require large datasets may increase worker monitoring which might negatively affect workers.

The monitoring function of AIWM, unlike more classical worker monitoring approaches, may allow employers to go beyond simply monitoring worker performance and activities to also monitoring their feelings, behaviour, wellbeing, social network presence and many other aspects (Ball, 2021; Eurofound, 2020b; Kellogg et al., 2020). Worker monitoring can be done through a variety of means, including, but not limited to, keystroke trackers, recording workers *via* video cameras or computer web cameras, and email analytics (Ball, 2021; Eurofound, 2020b; European Parliamentary Research Service, 2020a). Though the examples provided do not necessarily need AI to operate, AI can enhance monitoring/surveillance immensely by, for example, using AI-powered face recognition to more accurately monitor workers (Mateescu & Nguyen, 2019) or analysing worker speech patterns, or their emails to perform sentiment analysis and capture their emotional wellbeing (Calvo et al., 2017). However, this might lead to a lot of risks and issues, which are mentioned in the Barriers and risks subsection.

People or workforce analytics is an example of application of AIWM used to presumably improve decision-making about HR management aspects. It uses digital tools and data to measure, report and understand employee performance (Collins et al., 2019, p. 98). It deals with questions related to the appraisal of workers, recruitment, promotion and carrier development, to identify when people are likely to leave their jobs and to select future leaders, and to look for patterns across workers' data, which can help to spot trends in attendance, staff morale and health issues at the organisational level (EU-OSHA, 2019). It is also heavily related to worker rating tools, allowing companies to decide who performs 'better' and who performs 'worse' (Kellogg et al., 2020). For example, people analytics could be used to identify underperforming workers and replace them through automatic recruitment algorithms (Kellogg et al., 2020). It can also be used to help with recruitment in general through the screening of

[13] See: https://en.wikipedia.org/wiki/Virtual_assistant

CVs, cover letters, providing a recruitment test, as well as carrying out automated psychometric testing, interviews and much more (Brione, 2020; Vedapradha et al., 2019). However, the accuracy and unbiased nature of such approaches is highly debatable. For example, according to Fernández-Martínez and Fernández (2020), some AI-based systems that are trained based on previous recruitment data can further exacerbate the bias present in them rather than curb it. A similar issue was highlighted by several journals that managed to find that Amazon scrapped an AI recruitment system as it was biased against women (Dastin, 2018).

AI-powered prediction models, forecasting models that predict different factors related to workers, such as those used for people analytics, are often used to predict who in the staff is most likely to leave soon and hence should receive more attention from managers (Punnoose & Ajit, 2016). Going further, some organisations, such as IBM using their supercomputer Watson, use AI to get recommendations on actions that can be taken to prevent a worker from leaving (Fisher, 2019). However, it is also important to note that simple statistical analytics, such as regressions, can do the same. However, as some perceive AI-based prediction models to be more accurate, many organisations have started to move away from simpler approaches in favour of AI-based ones (Valle & Ruz, 2015)[14]. AI-powered prediction models are also sometimes applied to predict who in the company has the greatest potential and hence should receive more training and/or be given more demanding tasks (Mishra et al., 2016). Furthermore, combining prediction models with real-time worker monitoring can also be used to predict work accidents (Yedla et al., 2020), burnout (Grządzielewska, 2021) and similar (for more, see the subsection Improving worker health, safety and overall wellbeing. However, as with other approaches, they are not infallible, as they can produce biased results and may introduce unnecessary micromanagement into companies, which is a prime cause of stress and anxiety (Moore, 2018b).

Improving worker health, safety and overall wellbeing

Protecting the health, safety and wellbeing of workers is a legal obligation in the EU and it also, to some extent, has become a ‘corporate concern’ (Till, 2016) with many employers trying to reduce healthcare and insurance costs while simultaneously improving the productivity of workers (Ajana, 2020). Corporate wellness schemes also give work a ‘more human orientation’ (Moore, 2018a), by providing employees a chance for self-improvement and instilling norms of health and team values (Ajana, 2020). This is not a new idea, however; in recent decades, advancements in AI opened many new avenues for how worker health, safety and wellbeing can be ensured, and sometimes even improved, through AIWM systems.

If AIWM is implemented in a transparent, safe and ethical way, it could have a supporting function for management and workers’ representatives to optimise work organisation while providing information helpful in identifying OSH issues, including psychosocial risks, and areas where OSH interventions are required, by reducing the exposure to various risk factors, including harassment and violence, and providing early warnings of hazardous situations, stress, health issues and fatigue in relation to tasks and activities carried out by workers. AIWM systems can also provide individually tailored real-time advice that would influence workers’ behaviour to improve their safety and health. AIWM could therefore support evidence-based prevention and advanced workplace risk assessment and more efficient, risk-based, targeted OSH inspections.

The remainder of this subsection provides several broad examples of how AIWM can help to improve OSH, while a more in-depth review of the opportunities that AIWM creates for OSH is provided in EU-OSHA (2022a).

The majority of AIWM systems that may contribute to ensuring a healthy workforce can collect data about workers and the work environment in order to **identify risks to workers’ health, safety and wellbeing** and to help mitigate them (Belton, 2019; Till, 2016). For example, some organisations employ monitoring devices that measure the biometric information of workers to ensure that they are not fatigued (Gianatti, 2020), which might negatively affect their performance on the job and increase the probability of accidents (EU-OSHA, 2019). An interviewed expert in AI also stipulated that the monitoring function of AIWM together with sophisticated AI approaches can be used to determine a worker’s level of attention in dangerous situations and warn them if their concentration falls, which might prevent an accident. AI can also be used to create a plethora of tools that can solve very specific safety-

[14] For an overview of different machine learning models used in turnover prediction, see Punnoose and Ajit (2016).

related issues. For example, during the COVID-19 pandemic, Amazon created the Distance Assistant tool that checks if employees are maintaining social distancing and warning them if they are not (Porter, 2020). AIWM systems that screen emails or analyse facial micro-expression or a tone of voice can also be used to identify stress or poor emotional wellbeing in workers (Estévez-Mujica & Quintane, 2018).

In addition to the monitoring-centred systems, there are also several more proactive wellbeing-centred systems. Some new tools also reflect the new trend in worker management wherein some organisations provide the means for **workers to improve their emotional wellbeing**, which is connected to improved worker productivity (Oracle and Workplace Intelligence, 2020). An example of such AI-powered tools is mental health chatbots – software robots that can be used by workers to communicate about their mental health. Mental health chatbots operate by analysing the communication patterns of workers and estimating the probability of different psychosocial issues, such as mental distress (Cameron et al., 2017; Oracle and Workplace Intelligence, 2020; Zel & Kongar, 2020).

Some chatbots can also provide personalised mindfulness practices to workers who are at risk (Zel & Kongar, 2020). It is worth mentioning that although the idea of talking with a computer about mental health may seem foreign, according to Oracle and Workplace Intelligence (2020, p. 3), 68% of 12,000 surveyed employees, managers and HR managers in 11 countries (Brazil, China, France, Germany, India, Italy, Japan, Korea, the United Arab Emirates, United Kingdom and United States) would rather talk to a chatbot about their mental health than to a human manager. In addition, digital assistants can aid in dealing with feelings of isolation, especially during the COVID-19 pandemic by communicating with workers (Sheerman et al., 2020).

Some AI-based tools, heavily utilised in AIWM approaches such as gamification, aim at improving **worker engagement and/or job satisfaction** (Hughes et al., 2019) in a variety of ways. First, engagement and job satisfaction can be improved by monitoring and analysing worker data to reward workers for a job well done (Hughes et al., 2019). Second, these tools can be used for identifying what 'drives' the workers and giving them more autonomy to do what they like, showing more trust in them and allowing them to express themselves more (Schweyer, 2018). Third, they can better match workers with tasks and colleagues they enjoy working with (Kronos, 2018). These are only a few examples of how the engagement and satisfaction of workers can be improved through AIWM.

Barriers and risks

This subsection explores the difficulties of implementing AIMW tools, as well as the negative effects and risks they can create and how they can be curbed. It is structured as follows:

- Barriers to the uptake of AIWM – a short discussion on factors that hinder the implementation of AIWM tools.
- Risks of the application of AIWM – discussion on issues and risks that organisations must consider when implementing AIWM tools that might lead to negative OSH effects (an in-depth discussion on impacts will be provided in the Task 2 report).
- Trustworthy and ethical implementation of AIWM – discusses how to ensure that AIWM systems are not used in an unethical way and diminish the probability that they would lead to a negative OSH effect.

Barriers to the uptake of AIWM

According to some experts (for example, Dasgupta & Wendler, 2019; Eager et al., 2020), a wider adoption of AI in workplaces is hindered by the lack of a clear AI strategy, cultural resistance, the lack of knowledge needed for AI tools, budget constraints, and the size of the enterprise (for example, small enterprises do not need sophisticated worker management systems due to the small number of workers they employ and have to manage). Similar insights can be drawn from national surveys. For example, according to a Polish survey (Główny Urząd Statystyczny, 2020, p. 75), the main reasons why AI is not applied in organisations is the lack of a need to do so (71.1%), high costs (25.7%), lack of qualified staff (20.7%) and commitment to the 'traditional' way of doing business (19.6%). Based on this, as well as other sources (Chamorro-Premuzic, 2020; Mahidhar & Davenport, 2018; Reim et al., 2020), three main factors hinder the adaption of AIWM tools: (i) **lack of trust in AI**; (ii) **lack of skills, expertise and/or knowledge**; and (iii) **financial and other resource constraints**.

Regarding the **lack of trust in AI**, more often than not, both employers/managers and employees do not completely trust AI and the decisions it makes. From the employer/manager perspective, some see

AI as a barrier rather than a useful tool. According to OrgVue (2019, p. 11), around 55% of 400 surveyed decision-makers said that 'technology is a barrier to conducting effective workforce analytics.' From the workers' perspective, some of them feel eerie and anxious in a presence of, or communicating with, a human-like robot/computer system (Yogeeswaran et al., 2016). Many workers also do not trust AI because they are not sure how managers and employers are planning to use, or abuse, it (Chamorro-Premuzic, 2020). Similarly, in a 2017 global study 80% of surveyed workers claimed they would not be comfortable with AI acting as a supervisor or manager (PEGA, 2020). In addition, the need to build trust in AI is also at the forefront according to the EU High-Level Expert Group on Artificial Intelligence (2019b, p. 35), which in its report stipulates that 'it is important to build AI systems that are worthy of trust, since human beings will only be able to confidently and fully reap its benefits when the technology, including the processes and people behind the technology, are trustworthy.'

A further barrier is often a **lack of knowledge** in organisations on how to implement and use AI-based systems. From a managers' perspective, there is a shortage of HR professionals with strong analytical skills (Marler & Boudreau, 2017, OrgVue, 2019), which may hinder the adoption of sophisticated worker management systems (Rasmussen & Ulrich. 2015). Similarly, there is often a lack of knowledge on what exactly can be done with AI and what problems it can solve, which further hinders its adoption (Reim et al., 2020). To some extent, this problem could be mitigated by outsourcing the creation and implementation of such technologies. However, according to Bassi (2011), this might also heavily diminish the motivation of managers to see the tool succeed as they would be somewhat disconnected from it (that is, managers would not feel 'ownership').

From the workers' perspective, they also often lack the knowledge to understand sophisticated AI-based, or even simple statistics-based, worker management tools (Fernandez & Gallardo-Gallardo, 2020). To some extent, worker organisations and trade unions strive to mitigate this issue by heavily pushing that any tools that are implemented in the workplace are explained in understandable ways to the workers. Nevertheless, with AI systems, it might be a tall order as some of them (for example, deep learning) are able to build such complex algorithms on their own through self-learning that even the experts who programmed the approach on how such tools learn often do not completely understand the self-learned algorithm (Adadi & Berrada, 2018; Pasquale, 2015). However, this should not be used as a defence by managers to not share insights about such tools with workers as even with the most complex models the input and output of the tools can be easily explained in simple terms to workers.

Regarding **financial and other constraints**, smaller organisations often cannot afford such new worker management systems, which are expensive and require large time commitments to implement. In addition, for an AI system to truly be useful for a company it cannot be generic in nature and hence it must be adapted to its specific needs (Mahidhar & Davenport, 2018). However, this also requires a lot of time and resources as many AI systems require large volumes of training data from which they can learn (Mahidhar & Davenport, 2018). Large amounts of resources also need to be spent to train managers and workers to use the tool (Mahidhar & Davenport, 2018). In addition, it is often challenging to accurately estimate the true effect of AI-based systems (ITU, 2018), which makes it difficult to 'sell' the idea that AI-based systems would bring value to a company and/or its workers (Reim et al., 2020).

Risks of the application of AIWM

According to Eurofound (2020b, p. 35) systems such as AIWM that heavily rely on worker monitoring and/or surveillance, might 'inhibit creative thinking, limit independence of thought and induce stress-related illness.' Similarly, algorithmic and AI-based direction may provide recommendations that are unintelligible to workers, leading to their frustration, and restrictions that are too harsh, and put performance pressure on workers that might prevent them from social interactions with their peers, not to take a break when needed and similar (Kellogg et al., 2020).

For example, **replacing HR managers with AIWM might lead to feelings of isolation and loneliness in some workers as a result of decreased human interactions**. AIWM might also foster anxiety and stress in workers as the result of a lack of trust in the system and, in particular, if the data collected by such tools are also shared with managers. These issues are, for example, also associated with digital assistants provided to workers as such systems perform analyses of content of speech and messages (Lau et al., 2018).

AIWM might also make **scheduling more short-notice, unpredictable and unstable** for workers as they can create schedules in real time, forcing workers to **always be in 'stand-by'** as they might be needed at any time (Mateescu & Nguyen, 2019). Such AIWM scheduling systems may also generate overwork if the scheduling tool gives work to specific workers too aggressively, leading to job dissatisfaction or even physical ailments such as chronic fatigue (Bérastégui, 2021; Kellogg et al., 2020). Finally, if an automatic scheduling tool functions based on a rating system, where workers with high ratings get better shifts (Bérastégui, 2021), this might lead to lower-rated workers working more for less money to raise their rating (Bérastégui, 2021). This, in turn, might lead to some negative impacts on workers, including 'increased work-family conflict, income uncertainty, and higher work stress' (Mateescu & Nguyen, 2019, p. 10).

Similarly, AIWM approaches such as AI-powered **gamification** can lead to several OSH risks, such as **making workers overwhelmed, stressed and fatigued** due to the **constant push to perform better**, have good 'scores' and to 'never settle' (Newman, 2017). It can also be invasive as the system relies on the collection of data about employees' work patterns and behaviours to monitor their performance and provide, for example, personalised rewards and punishments, which might further induce stress (Mason, 2018). According to Kellogg et al. (2020), gamification can make the individuals who are being nudged feel inadequate. Gamification can also induce stress in workers due to its secrecy (that is, how exactly do they work, how do they decide on rewards/punishments) and its fast nature (that is, changing pay rapidly without informing workers as to why exactly their pay was changed) (Kellogg et al., 2020).

AIWM, through real-time recommendations and directions for workers on how they should do their job, might also **put pressure on workers to work faster, leading to more work-related stress, negative impacts on their physical health and accidents** (Moore, 2018a). For example, some Amazon employees have reported fainting from dizziness caused by the intense pace of work set by an algorithm (Wujciak, 2019). AI-based performance monitoring tools might also incentivise delivery workers, taxi drivers and other individuals working with vehicles to drive faster than is safe as then they will be rated more favourably, but, in turn, may also lead to more traffic accidents (Moore, 2018a). Similarly, workers operating dangerous equipment or working in dangerous environments, such as construction sites, may be compelled to work faster thereby increasing the probability of accidents. Increased speeds also forced some Amazon workers in the United Kingdom to avoid using the toilet because of the fear of receiving a warning for missing performance targets; this may also lead to a plethora of negative psychosocial effects (Organise, 2018), as well as negative physical health effects, such as fatigue and bladder problems. In addition, logistics companies also use GPS for tracking workers, including tracking the length of their rest breaks (Eurofound, 2020b), which might lead to stress and anxiety.

If workers' data collected by AIWM are used for decisions about their career development or even possible firing, they may feel under pressure to perform and may overwork (EU-OSHA, 2019). According to EU-OSHA (2019), 'people analytics are likely to increase workers' stress if data are used in appraisals and performance management without due diligence in its process and implementation, leading to questions about micro-management and workers feeling 'spied on'.' Micromanagement is a prime cause of stress and anxiety (Moore, 2018b).

In addition, AIWM facilitating AI-based decision-making creates the risk of **dehumanising workers and reducing them to behaving like machines** (Heaven, 2020; Moore, 2018a; Wujciak, 2019). More specifically, workers' decision-making capacity can be covertly subverted through nudging practices that are based on their personal data and can be manipulative and ethically questionable (Gal et al., 2020). Moreover, workers risk being objectified and treated like commodities, when monitoring turns labour into sets of data points, stripping workers of liberties to choose, and/or have a personality or emotions (Colclough, 2020). This is especially problematic with monitoring practices that invade workers' privacy, which negatively affects their creative thinking and limits independence of thought (Oliver, 2002). This dehumanisation can be referred to as the *'datafication'* of the workplace, where workers are not treated as living beings but as collections of objective digital data that they have produced while going about their work (Mai, 2016). Such a perception of workers threatens their right to exercise freedom as reasonable and self-determining agents who are capable of making decisions in accordance with their own levels of understanding, values and belief systems.

Organisations often **lack transparency** in terms of disclosing whether they use AIWM systems, and developers of AIWM systems lack of transparency about how they all work. Often, employees are also not aware they are being monitored or that an algorithm and not a person is evaluating their performance automatically (AlgorithmWatch, 2019), even though this is explicitly prohibited by the EU GDPR. More specifically, according to Eurofound (2020b, pp. 28-29), in a survey of around 6,000

Norwegian employees 40% of them mentioned that use of worker monitoring and surveillance was discussed with employee representatives, while 15% mentioned that it was not and 45% were not sure. In the same survey, around 54% of respondents also mentioned that their employers 'had informed them about the use of the information gathered about them' (Eurofound, 2020b, p. 29). Similarly, the Danish Union of Public Employees (Forbundet af Offenligt Ansatte) conducted a similar survey and found that 61% of individuals who had been monitored through video surveillance did not see any value in such actions (Eurofound, 2020b, p. 30). A recent (2020) survey of 7,750 trade union members in the United Kingdom also revealed that 48% of employees were not confident about the kind of data their employers collect on them (Eurofound, 2020b, p. 37). Finally, an interviewed expert in work and employment and a specialist in organisational surveillance also agreed that organisations are often non-transparent regarding worker monitoring.

Connected to the lack of transparency, a lot of workers, as well as academics, voice **concerns over data protection and privacy**. More specifically, algorithm-based worker management practices can be highly invasive and intrusive (De Stefano, 2020), blurring work-life balance as workers are 'always watched' even during their 'off' time (Eurofound, 2020a), thus violating the GDPR and peoples' privacy rights, which might have repercussions on human dignity. The worries about data protection are grounded in the fact that monitoring tools can access highly sensitive personal data, ranging from humour of workers and their mood to even more intimate information like medical history, the intention to become pregnant or the possibility to develop sickness (Ajunwa et al., 2017; De Stefano, 2020; Manokha, 2017). In addition, some AI-based tools can also infer information about individual behaviour, interests and personality, from publicly available data, such as posts on social media platforms (Access Now, 2018; Privacy International, 2017). This can be done without the consent or knowledge of data subjects (Financial Management, 2020), which might have implications for workers' wellbeing and employer-employee relationships. For example, a small-scale study of government employees in Malta found that the lack of communication from management about the introduction and implementation of monitoring systems exacerbated the feeling of mistrust between employers and workers (Garzia, 2013, as cited in Eurofound, 2020b).

In addition, the feeling or awareness of being observed or monitored can cause workers to act unnaturally, for example, to always smile or supress their true feelings, personality and/or preferences. For example, in Beijing offices of camera maker Canon, the managers installed a system that only lets smiling employees to enter the building or book conference rooms (Sun, 2021). Some other companies in China, such as China Mobile, China Unicom and Huawei, went even further by installing emotion recognition systems in the whole office to assess how happy workers are in the office, forcing workers to act over-enthusiastic (Teh, 2021). In the EU and the United States, emotional monitoring and assessment is less prevalent, but it also exists, as, for example, call agents working at MetLife, a global insurance company, must use a software that detects their emotional state and shows a heart symbol when the tool deems that they are using an appropriate tone (Mateescu & Nguyen, 2019).

It bears mentioning that when it comes to worker monitoring and privacy, the EU GDPR tries to mitigate the issues that might stem from it. According to the European Parliamentary Research Service (2020b, p. 79), 'the GDPR generally provides meaningful indications for data protection relatively to AI application.' However, it does not fully cover all relevant issues related to data protection, as, according to the European Parliamentary Research Service (2020b, p. 80): 'A broad debate is needed … to address the issues of determining what standards should apply to AI processing of personal data, particularly to ensure the acceptability, fairness and reasonability of decisions on individuals.' In addition, though organisations must comply with the GDPR, many do not. For example, according to a Thomson Reuters (2019) survey one year after the GDPR took effect, around 79% of surveyed businesses said that they are failing to meet the regulatory requirements. In recent years, compliance improved, but many organisations are still not compliant with the GDPR (see, for example, REaD Group (2021), McCann FitzGerald (2021), and Ruohonen and Hjerppe (2021) for more). Also, for more insights on the GDPR and other relevant regulations, see the Regulatory contexts and their relevance to AIWM and OSH chapter.

AIWM and algorithmic management tools might also **exacerbate rather than curb biases that exist in the organisation**, as is the case, for example, of some AI-based systems that are trained based on previous recruitment data (Fernández-Martínez & Fernández, 2020). Though a large portion of individuals perceive AI-based decision-making to be more objective than a human-based process, as it is based on sophisticated approaches and large volumes of data (Amoore & Piotukh, 2015; Ziewitz, 2015), in reality such approaches, which often learn and evolve from data, might amplify the biases and beliefs of the humans who have created them or the data on which they are trained (EU-OSHA, 2019; Deobald et al., 2019; World Economic Forum, 2018). This bias is especially prevalent in AI applications related to recruitment and employee evaluation. For example, the Amazon AI recruitment tool had to be scrapped as it favoured words more commonly used by male applicants in their CVs (such as ‘executed’ and ‘captured’) and penalised or downgraded resumes that included words that are more often attributed to women (Dastin, 2018). Another example is the HireVue tool that was proven to be biased towards heterosexual white males, a group that had enjoyed preferential treatment in the previous hiring of (heterosexual white men) managers (Feloni, 2017). Similarly, according to Fernández-Martínez and Fernández (2020), many existing voice and facial feature analysis tools that are often used in both recruitment and employee assessment often give a more favourable evaluation to male candidates, individuals without regional accents and people with symmetric faces.

In addition, granting AI-based approaches large autonomy in decision-making might lead to issues related to **accountability** (Brione, 2020). More specifically, even though, according to the GDPR, automated decision-making that might have a legal or other significant effect on data subjects is prohibited, some organisations might find a loophole to circumvent this, which raised the important question of who is liable when a decision that was made based on AI leads to negative OSH-related effects (Gluyas & Day, 2018; Martin, 2018). Some scholars stipulate that managers should be accountable as they decide how the information, recommendations and decisions from AI-based tools are used (Brione, 2020). This logic can be extended to finding out ‘who to blame’ for discriminatory and biased algorithms. However, given that managers often lack the know-how to fully understand such tools (Adadi & Berrada, 2018; Pasquale, 2015), they may sometimes fail to identify the bias and the problem.

Trustful and ethical implementation of AIWM

The aforementioned issues indicate that many factors need to be considered to ensure that AIWM is not misused or does not lead to a plethora of risks and negative consequences. Nevertheless, it is possible to successfully implement useful AIWM systems that might contribute to better OSH if they are implemented in a transparent and ethical way, ensuring worker and worker representatives participation and consultation in all steps, including at the design stage, incorporating the OSH perspectives in the technologies, minimising worker data collection, ensuring workers’ safety and health, privacy and, in turn, dignity. According to interviewed experts, this can be achieved in many ways including but not limited to: (i) giving workers the tools to negotiate how their data are collected, analysed, stored and off-boarded/sold (for more, see Colclough, 2020); (ii) ensuring worker representation in the co-governance of AI-based systems (for more, see Colclough, 2020); (iii) building a clear line of responsibility of what should happen if an AI system leads to harm to humans; (iv) ensuring that AI system developers are transparent on how they operate; and (v) ensuring that such systems are developed, used and evaluated following a human-centric approach.

Additionally, and more formally, a trustworthy and ethical implementation of AI-based systems, which subsequently includes AIWM, according to the High-Level Expert Group on Artificial Intelligence (2019b) can be ensured if it follows the following four principles:

- **Respect for human autonomy** – AI systems should follow a human-centric design that fosters humans’ cognitive, social and cultural skills and it should not manipulate, deceive or take away autonomy from them.
- **Prevention of harm** – AI systems should not bring or exacerbate any physical or psychosocial harm to humans. This also entails trying to prevent harm to nature.
- **Fairness** – AI systems should provide equal opportunities to humans and not discriminate, as well as not take away the freedom of choice. This principle is closely related to the AI decision-making discriminatory bias previously discussed.
- **Explicability** – AI systems should be as transparent as possible and provide as much information as possible on the logic behind their results to ensure that decision-makers can duly evaluate them.

To some extent, these are already ensured by existing regulations such as the GDPR that covers data protection and automated decision-making. Nevertheless, not all organisations are compliant with these rules, as was mentioned prior (see the Risks of the application of AIWM subsection), and hence more needs to be done. For insights on gaps and needs in the regulations, as well as how they can be mitigated, see the Regulatory contexts and their relevance to AIWM and OSH chapter.

Who uses AIWM systems?

AIWM entails a myriad of tools, techniques and practices, making an analysis of its uptake difficult, especially as there is no singular database that measures it. Besides this, some organisations might not completely understand what kind of AI tools they are using or if the tools they are using are AI-based at all, especially if they are buying/renting them from third parties (Tambe et al., 2019), while others might not be willing to discuss their use of them openly (Chamorro-Premuzic, 2020). Because of this, the uptake of AIWM, predominantly, can only be inferred from the implementation of different AI-based, or adjacent, technologies that organisations might use for worker management.

One thing that can be said for certain is that the use of AI technologies in organisations is rising (Juniper Networks, 2021; Oracle, 2019), although the available research does not agree on how many organisations are currently using AI. For example, according to McKinsey (2020, p. 2), around 58% out of 2,395 surveyed companies in 2019 have adopted AI in at least one area inside their company, including worker management. Similarly, according to a study carried out by Oracle (2019, p. 3), around 50% out of the 8,370 HR leaders, managers, and employees across 10 countries, interviewed about their attitudes toward and behaviours regarding AI reported that they were using AI in some form in their work in 2019. However, according to Juniper Networks (2021, p. 3), although 95% of the surveyed 700 individuals with direct involvement in their organisation's AI and machine learning plans or deployment across different levels and industries state that they would benefit from integrating AI in their day-to-day work, only 22% of organisations actually use AI systems. In a more extreme example, according to the MMC Venture (2019, p. 99) report, only around 1,580 of 2,830 (around 56%) 'AI-based' start-ups – that is, start-ups that call themselves AI-based – from 13 EU countries[15] in reality use AI. Similarly, several interviewed academic experts in AI also highlighted that even though some statistics might imply a relatively large uptake, in reality, a majority of organisations are using simple algorithms and mistaking them for AI. A similar opinion was voiced by an interviewed business representative who stated that AI is not used that frequently by organisations and that early adopters will not be organisations from some sectors or of a specific type but those that are the most innovative.

Nevertheless, additional insights can be also drawn from ESENER-3[16] and ECS-2019[17] that have questions related to digital technologies normally used to enable AIWM. For example, ESENER-3, conducted in 2019, includes a question that covers different digital technologies that can enable AIWM and therefore can serve as a proxy for the uptake of AIWM, which is outlined in Table 1.

Setting the first two technologies (that is, personal computers and laptops) aside as they are used by many companies without any AI integration, a smaller number of workplaces utilise technologies that are more explicitly available to enable AIWM. This is the case for both unweighted and weighted data – normalised samples that take into control international differences[18]. Regarding the usage of robots that interact with workers, which can be only tentatively considered to enable AIWM, only 4% of workplaces (based on weighted data) use such technologies. Regarding AI-based technologies that are more closely connected to worker management and therefore more likely to be used to enable AIWM systems, only 12% of workplaces use systems that determine the content and pace of work, 8% use systems that monitor worker performance and 5% use wearable devices.

[15] Austria, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, and United Kingdom.

[16] For a methodological overview of how ESENER-3 is used, see Annex III – European Survey of Enterprises on New and Emerging Risks 2019 (ESENER-3) analysis.

[17] For a methodological overview of how ECS-2019 is used see Annex IV – European Company Survey (ECS-2019) analysis.

[18] Data was weighted using the estex variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).

Table 1: Workplaces that use digital technologies by type of technology (%; EU-27, 2019 - ESENER-3 Q310[19])

Types of technology used (ESENER-3 Q310 answers)	Weighted answers *	
	Yes	No
Personal computers at fixed workplaces	87%	13%
Laptops, tablets, smartphones or other mobile computer devices	77%	23%
Robots that interact with workers	4%	96%
Machines, systems or computers determining the content or pace of work	12%	88%
Machines, systems or computers monitoring workers' performance	8%	92%
Wearable devices, such as smart watches, data glasses or other (embedded) sensors	5%	95%

Source: Authors' elaboration on ESENER-3 data.
N = around 37,333 (for more, see Annex III – European Survey of Enterprises on New and emerging Risks 2019 (ESENER-3) analysis.
Note: Data was weighted using the estex variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).

Similarly, ECS-2019 asked a question about the percentage of employees for whom the pace of work is determined by a machine or a computer (Cedefop & Eurofound, 2019a, p. 8) and that can also be used as a proxy for the uptake of AI-based and algorithmic worker management systems. According to the results, as seen in Table 2, around 46% of surveyed workplaces use machine- or computer-based systems to determine the pace of work for at least some workers. Nevertheless, these results have to be looked at with much reservation as machines without AI integration might also determine the pace of work (for example, programmers have to wait for software to be compiled, manufacturing workers have to wait for machinery to do something).

Table 2: Workplaces that use machines or computers to determine the pace of work of employees (%; EU-27, 2019 - based on ECS-2019 variable PCWKMACH)

For how many employees pace of work is determined by machines or computers? (ECS-PCWKMACH)	Weighted answers*
None at all	54%
Less than 20%	16%
20% to 39%	9%
40% to 59%	7%
60% to 79%	5%
80% to 99%	4%
All	5%

Source: Authors' elaboration on ECS-2019 data.
N = 20,628
Note: Weighting was done using the *5_wgt_final* variables from ECS-2019, which is recommended for use to account for sampling and other errors (Cedefop & Eurofound, 2019b).

Results of analysis on ESENER-3 and ECS-2019 data provide some general insights on the uptake of AIWM solutions, although they are devoid of nuance. Hence, to get a better understanding of actual uptake, the remainder of this subsection explores it in terms of countries and economic sectors as well as by other company characteristics (for example, size, public vs private), and types of workers and work.

[19] Does your establishment use any of the following digital technologies for work? (i) Personal computers at fixed workplaces; (ii) Laptops, tablets, smartphones or other mobile computer devices; (iii) Robots that interact with workers; (iv) Machines, systems or computers determining the content or pace of work; (v) Machines, systems or computers monitoring workers' performance; (vi) Wearable devices, such as smart watches, data glasses or other (embedded) sensors.

Countries

According to interviews with several experts in AI and worker management, workplaces from countries with more mature economies in the EU will be the first to widely adopt new forms of AIWM tools, while workplaces from other countries in the EU will follow suit after. However, according to ESENER-3 and ECS-2019 data, it seems there is no clear geographical pattern in terms of the adoption of technologies enabling AIWM. For example, mapping the usage of technologies that are mostly related to worker management among all technologies covered in ESENER-3 (that is, technologies that determine the content and pace of work and technologies that monitor workers' performance) reveals that their usage is spread out across different EU regions without any clear clusters (see Figure 1 and Figure 2). In addition, it does not seem that usage of different technologies is heavily interconnected as can be seen in Figure 1 and Figure 2 as well as in Table III-2 in Annex III. More specifically, on the one hand, Malta, Hungary, Greece, Finland and Ireland are countries that, according to ESENER-3's weighted data, employ the most systems for determining the content and pace of the work of workers (25%, 24%, 22%, 19% and 18%, respectively). On the other hand, Finland, Belgium, Lithuania, Ireland and Denmark are the countries that most often employ workers' performance monitoring tools (23%, 22%, 20%, 18% and 16%, respectively). A similar trend is observed with other technologies outlined in ESENER-3. (For more, see Table III-2 in Annex III).

Figure 1: Workplaces that use machines, systems or computers determining the content or pace of work (%)

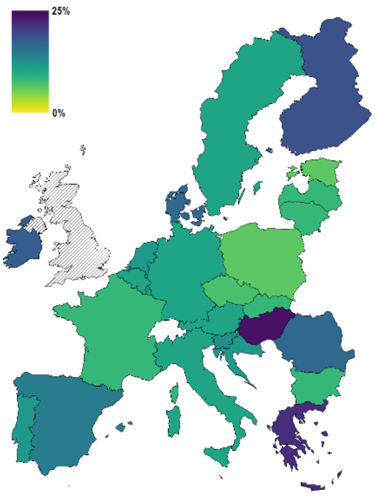
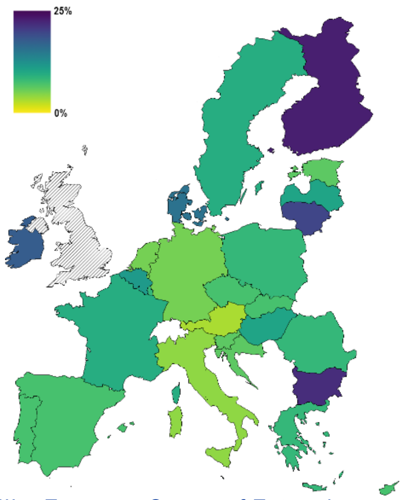


Figure 2: Workplaces that use machines, systems or computers monitoring workers' performance (%)



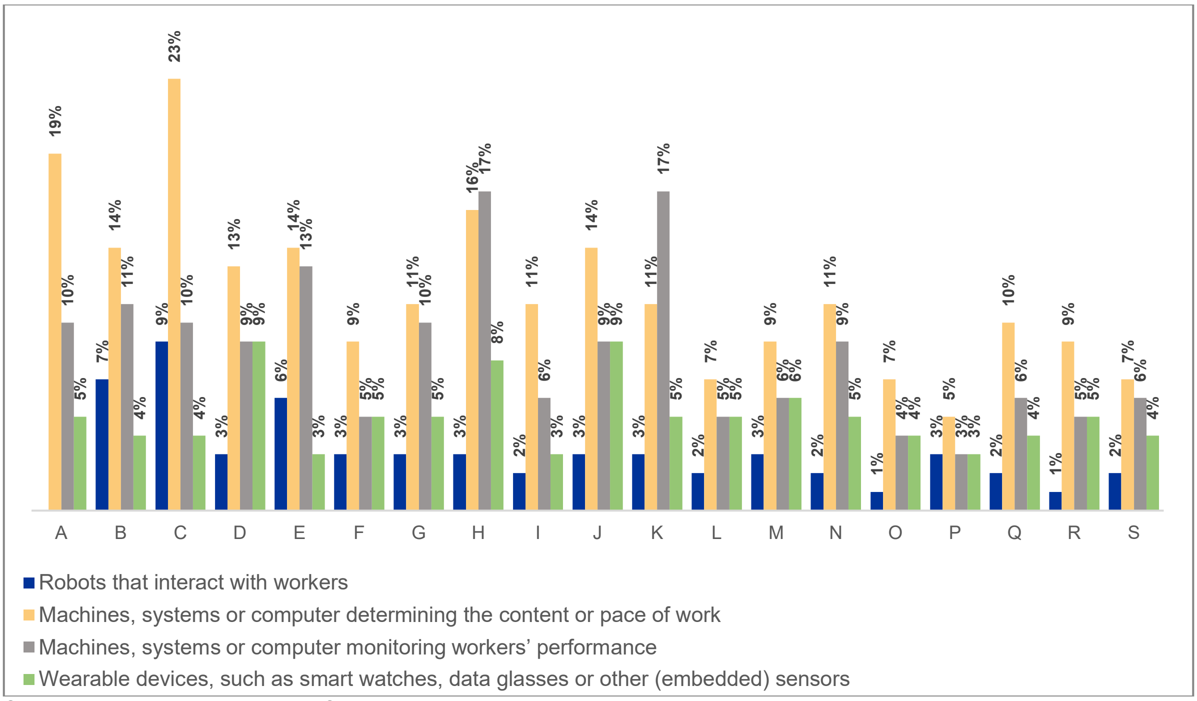
Source: Authors' elaboration on ESENER-3 data. (For more, see Annex III – European Survey of Enterprises on New and emerging Risks 2019 (ESENER-3) analysis)
Note: Data was weighted using the *estex* variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).

Data from the ECS-2019 survey shows that countries with a GDP per capita that is higher than the EU average are less likely to have systems where the pace of work is determined by a machine or computer. For example, the top three countries where the pace of work is determined by machines or computers for at least a group of workers are Croatia (76%), Latvia (74%) and Greece (73.9%), while the top three countries for which no work is determined by machines or computers are Germany (30.8%), France (32.4%) and Luxembourg (34.9%) (see Table IV-2 in Annex IV for more). Results from the regression using ECS-2019 data show largely similar results (see Table IV-5 in Annex IV).

Sectors

During their interviews, experts in algorithmic management, worker management and human-technology synergies predominantly mentioned healthcare, logistics (that is, transportation and storage), and manufacturing sectors as the ones that are most likely to use, and will continue to use, AI-based new forms of worker management tools. To an extent, ESENER-3 data support this, as sectors that are manual in nature, such as agriculture (A), mining and quarrying (B), and manufacturing (C), tend to use more robots that interact with workers and machines, systems or computers determining the content or pace of work (see Figure 3). However, workplaces in the construction sector (F) relatively rarely employ technologies covered in ESENER-3. In addition, when it comes to systems that can be used to monitor worker performance, the transportation and storage sectors (H) and financial and insurance activities sector (K) are at the forefront. It also bears mentioning that, unlike the interviewed experts' stipulations with regards to the healthcare sector (Q), workplaces in this sector tend to implement technologies that can be connected to worker management relatively rarely compared to other sectors. Results from the regression analysis (see Table III-5 and Table III-6 in Annex III) in general support these claims.

Figure 3: Workplaces that use digital technologies by type of technology and economic sector (NACE Rev. 2[20]) (%; EU-27, 2019)



Source: Authors' elaboration on ESENER-3 data.
Note: Data was weighted using the *estex* variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).

ECS-2019 data provide largely similar results as, according to it, in around 68% of workplaces in the mining and quarrying as well as manufacturing sectors, computers or machines determine the pace of work. For organisations from other sectors, the pace of work is determined less frequently. Sectors where machines and/or computers determine the pace of work most rarely include real estate activities (30%), financial insurance activities (33%), and art, entertainment and recreation (35%). For more insights, see Table IV-3 in Annex IV.

Size

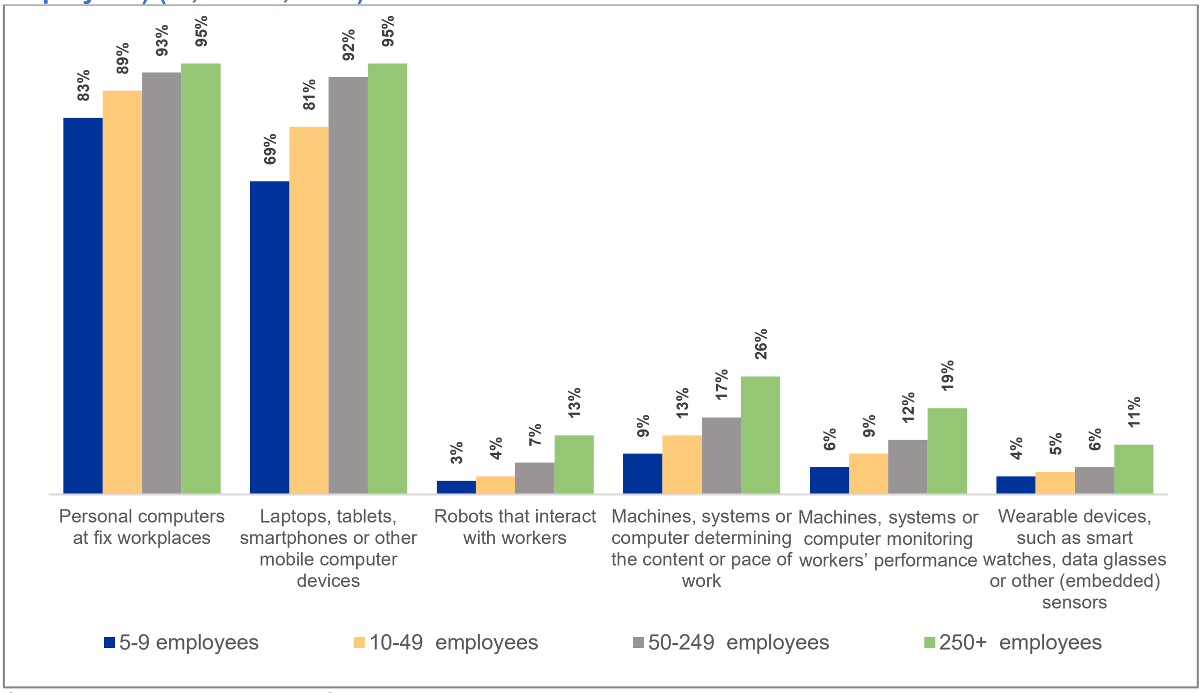
According to several interviewed experts in AI, larger workplaces are more likely than smaller ones to employ AIWM tools due to their need to manage, and often control, a large workforce. Both the academic and grey literature also heavily support this claim since large companies from a variety of sectors, such as Amazon, Barclays and MetLife, are at the forefront of using worker management, and

[20] NACE Rev. 2 sectors: A – Agriculture, Forestry and Fishing; B – Mining and Quarrying; C – Manufacturing; D – Electricity, Gas, Steam and Air Conditioning Supply; E – Water Supply; Sewerage, Waste Management and Remediation Activities; F – Construction; G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H – Transportation and Storage; I – Accommodation and Food Service Activities; J – Information and Communication; K – Financial and Insurance Activities; L –Real Estate Activities; M – Professional, Scientific and Technical Activities; N – Administrative and Support Service Activities; O – Public Administration and Defence, Compulsory Social Security; P – Education; Q – Human Health and Social Work Activities; R – Arts, Entertainment and Recreation; S – Other Service Activities.

especially worker monitoring, technologies (Eurofound, 2020b; European Parliamentary Research Service, 2020a; Mateescu & Nguyen, 2019; Wujciak, 2019). Data from ESENER-3 and ECS-2019 also support these conclusions.

According to ESENER-3, the larger the size of the workplace, the more common the utilisation of different digital technologies. This is also true for technologies that many companies utilise not necessarily with AI integration, such as personal computers, laptops and tablets, as well as technologies that are more likely to be used to enable AIWM, such as robots, machine systems that determine the content or pace of work, monitoring tools and wearable devices. The regression analysis results also support this trend. See Table III-5 and Table III-6 in Annex III, as according to them, an increase in company size also leads to a higher odds ratio that a company is using worker management-related technologies.

Figure 4: Workplaces that use digital technologies by type of technology and size (number of employees) (%; EU-27, 2019)



Source: Authors' elaboration on ESENER-3 data.
Note: Data was weighted using the *estex* variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).

The ECS-2019 data analysis shows, in general, similar trends. According to it, the larger the workplace, the more likely the use of machines or computers to determine the pace of work (see Table IV-4 and Table IV-5 in Annex IV).

Other organisational characteristics

Based on other organisational characteristics, some additional insights can be derived.

Firstly, according to ESENER-3, public organisations use personal computers or laptops more commonly than private organisations. When it comes to technologies enabling AIWM, including machines, systems or computers determining the content or pace of work, machines, systems or computers monitoring workers' performance, and wearable devices, such as smart watches, data glasses or other (embedded) sensors, private workplaces are slightly more likely to use such technologies than public ones. To some extent, these differences could be attributed to the types of companies operating in the public and private sectors, where, for example, many organisations in construction, accommodation and manufacturing are often private and a comparatively small percentage of employees in these sectors use computers and computer technologies (see Table III-3 in Annex III for more).

Secondly, according to ESENER-3, the use of digital technologies does not seem to be related to the presence of any types of employee representation (work council, trade union representative, health and safety committee, or health and safety representative)[21]. According to the data, around 89% of workplaces, irrespectively of type of worker representation, use computers, around 85% use laptops, tablets and similar, around 5% use robots, around 14% use machines to determine the content or pace of work, around 12% use machines to monitor workers' performance, and around 6% use wearable devices (see Table III-4 in Annex III for more). Conversely, it is worth noticing that workplaces *without* any type of worker representation use technologies enabling AIWM less frequently than workplaces with worker representation bodies. However, this might simply be that organisations without representation are often smaller and do not adopt such technologies for a variety of reasons. This is supported by the regression analysis results indicating that the size of a company has a certain impact on the implementation of digital technologies, while the type of representation does not if the size is kept constant.

Finally, according to ECS-2019, younger organisations use technologies that determine the pace of work of workers more often, though differences are relatively minor. More specifically, around 51.1% of organisations that are 10 years or younger surveyed in the ECS-2019 do not use such technologies, whereas 56.6% of organisations that are 30 years or older do the same (see Table 10-4 and Table 10-5 for more). In addition, according to ECS-2019, workplaces that have a worker suggestion scheme – a system where workers can provide their suggestions in a formal way – do not use technologies to dictate the pace of work in 51.7% of cases, while 55.8% of organisations that do not have such schemes use these technologies. The differences could be due to several reasons, including the differences in company size as smaller companies more rarely used such suggestion schemes. For more insights on these and other findings discussed, see Annex III – European Survey of Enterprises on New and emerging Risks 2019 (ESENER-3) analysis and Annex IV – European Company Survey (ECS-2019) analysis.

Type of workers and work

Regarding types of workers, according to interviews with experts in AI, worker management and OSH, **individuals working in occupations with many routine tasks are most susceptible to AIWM**, which is corroborated by the literature (for example, see European Parliament, 2019). For instance, systems that monitor worker performance and allow employers to compare their results work best with workers from blue-collar occupations that perform repetitive tasks where the work is relatively uniform and is devoid of creativity (Heaven, 2020). Most well-known cases of workers being managed using AI come from warehouses, retail, or delivery and logistics services. These workplaces are usually made up of low-wage blue-collar workers who work as drivers, shop employees, deliverers or warehouse staff. Echoing this, according to Dzieza (2020), companies that pursue highly automated worker management based on AI are typically made up of 'a large pool of poorly paid, easily replaced, often part-time or contract workers at the bottom … [and] a small group of highly paid workers who design the software that manages them at the top' (para. 23).

However, evidence points out that **white-collar occupations, especially those that have more routine tasks, are also susceptible to algorithmic or AI-based management**. For example, due to the COVID-19 pandemic, a lot of workers, predominantly white-collar ones, moved to working from home, which led to many employers introducing more intrusive worker monitoring and performance analytics tools to ensure that workers were not shirking (Boiral et al., 2021; Gigauri, 2020). Before the COVID-19 pandemic, some white-collar workers were also heavily managed using algorithmic and AI management, such as call centre workers who are often managed using different tools, including AI-based ones that, for example, evaluate the speech patterns of workers to force them to sound more enthusiastic (Mateescu & Nguyen, 2019; Teh, 2021). Similarly, according to ECS-2019 and ESENER-3, several sectors that employ a large amount of lower-skilled white-collar employees use a comparatively large number of technologies that can be linked to algorithmic and/or AIWM management. For example, according to ESENER-3, around 17% of organisations from the financial sector and from the transportation and storage sector use technologies that monitor worker performance, while this number is closer to 10% or lower in other sectors (for more, see Table III-3). Similar insights can be seen in the ECS-2019 data (see Table IV-3). Nevertheless, higher-skilled individuals have more say in how they are managed, as, according to an interview with an expert in the

[21] It is important to note that the presence of one type of representative does not mean that another type of representative is not present; it simply indicates that a company has a specific type of employee representation in the company.

field of future of work, such workers are not easily replaceable as hence they can put pressure on employers to ease the use of AIWM tools if they do not like it. It can also be implied that workplaces with strong trade unions might also be able to negotiate more favourable worker monitoring, surveillance and or AI-based management arrangements with the employer.

Regarding the type of work, **algorithmic management is reported to be more frequently associated with digital labour platforms, also known as gig work** – systems where organisations or individuals hire workers to perform very specific, often short, assignments (Bérastégui, 2021). This predominantly includes managing, or probably more accurately, controlling the workforce through different apps, such as is the case in on-demand taxi services (for example, Uber[22], Lyft[23]), on-demand food delivery (for example, Uber Eats[24], Postmates[25]), on-demand freelance help (for example, fivver[26], Upwork[27]), and so on. This control can take many forms, however it predominantly involves rating systems that evaluate a worker's performance, GPS systems that track workers' positions and similar (Bérastégui, 2021). However, some organisations might go beyond this, such as those that only hire freelancers who agree to install highly intrusive worker monitoring software on their home computers (O'Donovan, 2018).

It is also worth mentioning that in recent years this practice has started to move beyond digital platforms to more 'traditional' workspaces (Mateescu & Nguyen, 2019a) also partly in connection with the growing prevalence of telework, mobile work and other fluid working arrangements (De Stefano, 2020; EU-OSHA, 2020a), which was further accelerated by the COVID-19 pandemic (Boiral et al., 2021). For example, some organisations are also starting to use different apps to manage their workforce who are not working from offices, such as Publicis Groupe – a French multinational advertising company – that uses a tool called Marcel that connects over 80,000 of their employees allowing them to cooperate, but also allowing the company to 'keep tabs' on them (Publicis Groupe, 2018). Similarly, according to an interview with representatives from a French national research institute for OSH, some French hospitals are starting to use apps that share the schedule of all of their workers and send alerts when there is demand for a particular type of worker. Hence, because of the blurred line between 'traditional' working arrangements and 'non-traditional' ones (telework, digital work, mobile work), it can be expected that the introduction of AIWM systems in these two types of work arrangements should follow a similar pattern (Bérastégui, 2021).

3.2 Effects of the COVID-19 pandemic on the implementation of AIWM

Several effects of the COVID-19 pandemic on worker management can be highlighted based on interviews, surveys and the literature review. First of all, a large portion of the workforce moved to telework. According to the Joint Research Centre (JRC, 2020), cited in EU-OSHA (2021, pp. 8-9), around 25% of employees were working remotely in 2020 during the outbreak compared to 15% before it. Similarly, according to Eurofound (2020c), cited in EU-OSHA (2021b):

> *'[…] in July 2020, nearly half of respondents classified as employees (48 %) worked at home at least some of the time during the COVID-19 pandemic. Of these, over one third (34 %) reported working exclusively from home. Overall, this study estimates that 39.6 % of paid work by dependent employees was carried out at home during the pandemic.' (p. 9)*

This, in turn, according to multiple EU-OSHA FOPs survey responses, **accelerated the need to improve the management of telework and mobile work**, a claim that is also supported by the academic literature (for example, see Boiral et al., 2021; Gigauri, 2020). In addition, in Poland, the COVID-19 pandemic prompted a discussion on the legal basis of work and how the Polish Labour Code could be amended to specify the maximum amount of work time, as well as to define safe working conditions in the context of work from home. According to the FOP representative from Poland, there is a major need for these changes as before the COVID-19 pandemic the regulations did not indicate, for example, what to do in case of an accident at work. According to the FOP survey, similar discussions

[22] See: https://www.uber.com/lt/en/
[23] See: https://www.lyft.com/
[24] See: https://www.ubereats.com/
[25] See: https://postmates.com/
[26] See: https://www.fiverr.com/
[27] See: https://www.upwork.com/

and legal developments can be observed in several other EU countries in addition to Poland, including Greece, Latvia, Lithuania, Portugal and Finland.

Several interviewed experts also highlighted that the COVID-19 pandemic led to **more organisations implementing telework and mobile work management tools**. For example, several interviewed experts from the fields of the management and social innovation of workers and employment agreed that due to the sudden shift to telework many organisations started to quickly buy and license worker monitoring tools. Such tools are often called 'tattleware', as they are very intrusive and allow employers to monitor workers all the time (Kelly, 2021). Hence, some believe that this might lead to negative effects on OSH. For example, a professor of management highlighted the issue of invasion of privacy fostered by monitoring tools used to monitor workers at home, which blurs the lines between work, home and private life, in particular in the case of telework and remote work. Similarly, one of the experts also expressed the fear that the end of the pandemic will not necessarily lead to less excessive monitoring as many organisations might want to continue to know more about their workers.

Nevertheless, an interviewed academic expert on the future of work mentioned that some of these negative effects could be counteracted through the **shifting dynamics in industrial relationships** brought on by the COVID-19 pandemic. More specifically, according to the aforementioned expert, many professionals and highly skilled employees who had the chance to work from home will still prefer to do so after the pandemic and they will also push against intrusive monitoring. Given that these types of employees are not easily replaceable, many organisations might, and some already did, allow these workers to telework indefinitely, also seeing the benefits of this in terms of cost cutting (EU-OSHA, 2021). This is supported by recent reports as, for example, according to the Microsoft corporate report (Wiseman, 2021), over 70% of workers wish to have a flexible remote work option, which Microsoft decided to provide to their employees after the pandemic. Many other, predominantly technology-based, companies, such as Siemens (Kelly, 2021), Deutsche Bank (Black & Schaefer, 2021), Google (Provenzano, 2021) and similar, also provide flexible remote work arrangements, while some companies, such as Facebook, allow workers to permanently work from home (Duffy, 2021). According to the aforementioned expert, many employers will also not be able to get away with highly intrusive monitoring of such high-skilled workers who can go relatively easily to competitors that offer better working arrangements.

Finally, one interviewed expert and the academic literature also highlight that the COVID-19 pandemic caused a significant number of workers feel **isolated and socially excluded**. More specifically, an interviewed professor of management mentioned that it is crucial for managers to provide social support to workers during the pandemic. Similarly, Boiral et al. (2021) also note that a lot of academic literature in this field highlights the importance of communication during this period. Connecting this issue to worker management, which also includes ensuring worker wellbeing that leads to higher productivity, some AIWM systems could help workers to cope with isolation and exclusions, such as AI-powered chatbots (Loveys, 2019; Sheerman, 2020). However, it bears mentioning that an over-reliance on chatbots could also lead to some OSH challenges. However, a recent meta study on the effectiveness and safety of using chatbots to improve mental health did not find any evidence that such a tool had any adverse effects on a user's mental health (Abd-Alrazaq et al., 2020).

3.3 Potential future developments of AI and AIWM

Some scholars (for example, Dilmegani, 2021; Tegmark, 2017; Vrontis et al., 2021) predict a bright future for AI and AIWM systems, being able to mimic human intelligence, which will allow to solve problems requiring cognitive decision-making abilities. More on this will be available in the upcoming EU-OSHA (2022b) report. However, other academics are more sceptical given that the development of AI was also full of many failures. For example, Fjelland (2020) argues that advancements in machine learning and similar gave humans, to an extent, the ability to transform tacit knowledge into a computer understandable form that allows for more creative decision-making. However, in reality AI can only mimic a small part of human intelligence. This is because, as Fjelland (2020, p. 3) quotes Dreyfus (1986), 'computers are not in the world', which means that they 'do not grow up, belong to a culture, and act in the world', which prevents them from acquiring human-like intelligence. Strickland (2019) expresses similar ideas by discussing why IBM Watson Health did not manage to mimic doctors, while Marcus (2019) highlights the failures of Alphabet's (a.k.a. Google) DeepMind in questions related to health and clean energy. Hence, because of this lack of consensus, it is very important to be restrained in predictions about the future of AI and AIWM systems. Yet, it is worth discussing some predictions on the future of AI and specifically on AIWM in academic literature that were mentioned by some interviewed experts.

As **remote working becomes common practice, companies are expected to invest more in the technology behind AIWM, especially for tracking employee performance** (Sostero et al., 2020). The **quick development of technologies like wearables and biometric technologies** that are becoming more sophisticated and affordable will empower employers to monitor their workers in an increasingly intrusive way (Eurofound, 2020b; European Parliamentary Research Service, 2020a). An interviewed market change expert and an expert in algorithm management also highlighted that in some organisations where **lower-skilled individuals who do not have a lot of bargaining power** are employed, these tools might remain in place after the pandemic. This, in turn, might lead to a plethora of negative psychosocial effects such as inducing stress and anxiety in workers due to excessive monitoring (Eurofound, 2020b; European Parliamentary Research Service, 2020a; Todoli-Signes, 2020). This is also connected to a **trend of more intrusive monitoring/surveillance of workers** (Soto-Acosta, 2020). For example, **in the biometrics field, there has been a 'growing impulse' to identify emotions** and other states such as exhaustion and concentration levels based on external appearances (Cater & Heikkilä, 2021; Imre-Millei, 2021).

In addition, **the introduction of 5G communication technologies could take the application of AI-assisted emotion recognition one step forward** by allowing the detection of 'human emotions using wireless signals and body movement' (Incheon National University, 2021, p. 1). For example, Fujitsu recently developed a facial recognition system that can detect micro changes in muscle movements in a person's facial expression that indicate their level of concentration, which can be used to detect how focused workers are (Adrill, 2021). Though Fujitsu's technology is still not widely used, it may become much more prevalent in the near future. The possible spread of such technologies in the future is also supported by expert predictions as, for example, according to a report by Wright (2021), the emotion recognition industry is expected to reach US$37 billion by 2026, compared to US$12 billion in 2018[28]. Nevertheless, **given the sensitive nature of this topic and discussions surrounding it** (for example, see Kelion (2019) or Malgieri and Ienca (2021)) **future regulations might put a stop to this type of monitoring at the EU level**.

Moreover, **AIWM systems of the future might be able to not only solve very specific problems but also deal with more creative, human-centric, issues** (Dilmegani, 2021; Tegmark, 2017; Vrontis et al., 2020), even though some academics believe this is unlikely to happen (for example, Fjelland, 2020; Marcus, 2019; Strickland, 2019). Connected to AIWM, this might include, for example, creating more personalised tools for each employee such as personal assistants that are not only able to help workers with their day-to-day tasks (Afshar et al., 2021; Bradley, 2020) but also provide companionship if they feel lonely (Oracle and Workplace Intelligence, 2020; Zel & Kongar, 2020). However, just like with any AIWM system, these developments, if they become reality, will also introduce new OSH risks and challenges that will have to be explored in depth.

These are only several possible developments of AIWM that might, or might not, come to fruition soon. Nevertheless, according to several interviewed experts, due to growing concerns regarding the future development of AI and AIWM, they stipulate that the EU will have to step forward towards more AI-centric regulations, including regulations limiting the possibility of such tools violating human rights and privacy, as well as mitigating any possible negative OSH-related effects they might create. Given the pace at which EU and national governments are currently moving, it seems these new AI-centric regulations, guidelines and policies that put humans and their wellbeing at the centre will become reality relatively soon, as is discussed in the next chapter 4 – Regulatory contexts and their relevance to AIWM and OSH.

[28] Please note that there are no current estimates for the EU-27. See: https://theconversation.com/ai-is-being-used-to-profile-people-from-their-head-vibrations-but-is-there-enough-evidence-to-support-it-160566

4 Regulatory contexts and their relevance to AIWM and OSH

This chapter provides an overview and discussion of policies, strategies, initiatives, programmes, codes of practices and guidelines that are implemented or under discussion at the EU or national level and that are relevant to the design, development, implementation and use of AIWM systems and OSH. The chapter is structured as follows:

- EU-level regulatory context – provides a summary of key EU-level efforts to regulate AI and its application, as well as insights on regulations relevant for AIWM and/or OSH.
- National regulatory context – provides an overview of national-level regulatory and non-regulatory initiatives in selected EU Member States.
- Gaps and needs for actions – discusses, in broad terms, how policies, strategies and initiatives could be improved and help to mitigate the negative effects of the use, and abuse, of AIWM in the context of OSH.

4.1 EU-level regulatory context and initiatives

Key EU-level regulations and initiatives on AI

Regulating AI is a key strategic priority for the European Commission, which aims to transform the EU to be 'the champion of an approach to AI that benefits people and society as a whole' (European Commission, 2018a, p. 2). Although there are no regulations at the EU level targeted specifically at AIWM, there are regulations related to AI and data management that are relevant to AIWM.

The EU has been especially active in addressing AI since 2018 by proposing and ratifying several legislative and non-legislative initiatives[29]. In 2018, the first two significant developments at the EU level came to fruition: **Declaration on Cooperation on Artificial Intelligence**[30], signed by 24 EU Member States[31] and Norway, and the **European Commission's Communication on AI for Europe**[32]. Complementary to each other, both documents addressed and aimed to create a common EU-level approach to AI. The two regulations had the goal of boosting the EU's AI capacity for the EU to become a global frontrunner in technological advancements and to address subsequent socio-economic transformations, as well as to ensure an adequate legal and ethical framework for the deployment of AI. Relevant to OSH are provisions in the communication addressing algorithmic decision-making (pp. 13-16 of the communication). The communication also acknowledges that the application of AI to decision-making and including it in the workplace may raise ethical and legal questions related to the liability and fairness of the decision-making. Considering the challenges that AI poses, the communication also notes that AI systems should be developed in a manner that allows humans to understand at least the basis of their actions.

The communication also sets the foundation for the creation of two formal advisory bodies on AI. First, the **High-Level Expert Group on Artificial Intelligence** (AI HLEG) was set up to support the Commission in implementing the European strategy on AI, including the elaboration of recommendations on future-related policy development and on ethical, legal and societal issues related to AI[33]. During its existence, the expert group managed to create several influential reports on AI that shape the discussion on it in the EU[34]. The second advisory body, **European AI Alliance**, a multi-

[29] It also bears mentioning that although some regulations that are relevant to AI existed before 2018, such as the Machinery Directive 2006/42/EC, concerns were raised that they were not suitable for AI-based systems (European Commission, 2018b).

[30] See: https://ec.europa.eu/jrc/communities/sites/default/files/2018aideclarationatdigitaldaydocxpdf.pdf

[31] Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and United Kingdom.

[32] See: https://digital-strategy.ec.europa.eu/en/library/communication-artificial-intelligence-europe

[33] See: https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai

[34] This includes: (i) Ethics Guidelines for Trustworthy AI; (ii) Policy and Investment Recommendations for Trustworthy AI; (iii) The final Assessment List for Trustworthy AI (ALTAI); and (iv) Sectoral Considerations on the

stakeholder forum (including trade unions, businesses, consumer organisations and other civil society bodies), was created to provide feedback to AI HLEG[35].

The communication also proposed **a Coordinated Plan on the Development of Artificial Intelligence** in Europe**,** which was accordingly drawn up later in 2018 (reviewed in 2021)[36]. The key goals of the plan are to maximise the impact of investments, encourage synergies and cooperation across the EU, foster the exchange of best practices and collectively define the way forward (European Commission, 2018a). The plan also provides the strategic framework for national AI strategies.

After that, in 2019 the **AI HLEG Ethics Guidelines for Trustworthy AI**[37] were released. On the same day (8 April), the European Commission released a **Communication on Building Trust in Human-Centric AI**[38]. The two documents highlighted the importance of building trust in AI by putting humans at the centre of it, as well as highlighted seven requirements that would ensure that an AI is trustworthy: human agency and oversight; technical robustness; safety, privacy and data governance; transparency; diversity, non-discrimination and fairness; societal and environmental wellbeing; and accountability.

Building on this, in 2020 the European Commission released a **White Paper on Artificial Intelligence – A European approach to excellence and trust**[39]. The White Paper sets out possible legal changes, proposing to create a legal definition of AI and to create new laws regulating 'high-risk' AI systems – systems that create an adverse impact on people's safety or their fundamental rights. Meanwhile, all other AI systems not posing a high risk should be subject to already existing laws. Relevant to AIWM, the White Paper mentioned the following tools as being high-risk: AI tools for worker recruitment, biometric identification, and surveillance. The White Paper was accompanied by the **European data strategy**[40] discussing how to deal with growing data, data accessibility and so on.

Building on the White Paper, on 21 April 2021 the European Commission drafted and published the first-ever attempt to create a comprehensive legal framework for AI – **Proposal for a Regulation on a European approach for Artificial Intelligence (a.k.a. the Artificial Intelligence Act)**[41]. The proposal was published alongside the **Communication on Fostering a European approach to Artificial Intelligence**[42], which draws attention to the aspect of trust in AI technologies and the need for a proportionate and risk-based European regulatory approach.

The regulation proposal aims to ensure the safe deployment of AI systems, prohibiting some of them while casting others as being high-risk and requiring more safeguards for the design, development and use of such systems. More specifically, Annex III of the document describes **high-risk AI systems**, which are relevant to AIWM, such as: (i) AI systems used for the recruitment or selection (that is, advertising vacancies, screening or filtering applications, evaluating candidates in the course of interviews or tests); and (ii) AI systems for making decisions on promotions and terminations of work-related contractual relationships, for task allocation, and for monitoring and evaluating the performance and behaviour of persons in such relationships.

Moreover, Chapter 2 of Title III introduces the following mandatory requirements for these high-risk AI systems:

- According to Article 9, providers must establish and maintain **risk management systems** throughout the life cycle of AI systems. This should ensure that these AI systems are trained with human oversight and on high-quality datasets that contain the least amount of bias possible.

Policy and Investment Recommendations. All of these reports are available at: https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai

[35] See: https://digital-strategy.ec.europa.eu/en/policies/european-ai-alliance

[36] See: https://ec.europa.eu/newsroom/dae/items/709091

[37] See: https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai

[38] See: https://digital-strategy.ec.europa.eu/en/library/communication-building-trust-human-centric-artificial-intelligence

[39] See: https://ec.europa.eu/info/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en

[40] See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0066

[41] See: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1623335154975&uri=CELEX%3A52021PC0206

[42] See: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0205&from=EN

- According to Article 10, high-risk AI systems that rely on the training of models with data have to be developed on the basis of training, validation and testing datasets. These datasets must be relevant, representative, free of errors and complete.
- According to Article 11, these systems should have the technical documentation drawn up (and kept up to date) before being placed on the market or put into service.
- According to Article 12, these systems should have automatic record keeping ('logs') to ensure a level of traceability of the AI system's functioning throughout its life cycle.
- Another requirement, according to Article 13, is that the operation of such systems is sufficiently transparent to enable users to interpret the system's output and use it appropriately. They should also come with concise, complete, correct and clear information that is relevant, accessible and comprehensible to users.
- According to Article 14, it is also required that these systems are designed and developed to have human oversight to prevent or minimise any risks to health, safety or fundamental rights that may emerge when a high-risk AI system is used.
- Finally, according to Article 15, an appropriate level of accuracy, robustness and cybersecurity of these systems should be ensured.

In addition, *Title III on High-risks in AI systems* in the proposal for regulation explicitly covers **health and safety** (European Commission, 2021, p. 13): 'Title III contains specific rules for AI systems that create a high risk to the health and safety or fundamental rights of natural persons.' Similarly, the proposal for regulation also specifically dictates that (European Commission, 2021, p. 20): 'In order to ensure a consistent and high level of protection of public interests as regards health, safety and fundamental rights, common normative standards for all high-risk AI systems should be established.' Finally, several articles in the document also heavily debate on topics that relate to AIWM, including the following extracts:

- **Title II Article 5.1** – recommends prohibiting the following practice relevant for AIWM (European Commission, 2021, p. 43): 'the placing on the market, putting into service or use of an AI system that deploys subliminal techniques beyond a person's consciousness in order to materially distort a person's behaviour in a manner that causes or is likely to cause that person or another person physical or psychological harm.'
- **Title III Article 7** – stipulates that if an AI tool has an impact on health and safety it cannot be considered to have a 'reversible effect' (European Commission, 2021, p. 46): 'the extent to which the outcome produced with an AI system is easily reversible, whereby outcomes having an impact on the health or safety of persons shall not be considered as easily reversible.'
- **Title III Article 9.5** – aims at diminishing the likelihood that high-risk AI systems lead to negative effects (European Commission, 2021, p. 47): 'high-risk AI systems shall be tested for the purposes of identifying the most appropriate risk management measures. Testing shall ensure that high-risk AI systems perform consistently for their intended purpose, and that they comply with the requirements set out in this Chapter.'

The document also refers to future developments in AI, based on which it can be adjusted. Indeed, this list of possibly harmful AI applications is by no means final. To ensure that the regulation can be adjusted to emerging uses and applications of AI, the Commission may expand the list of high-risk AI systems used within certain predefined areas by applying a set of criteria and risk assessment methodology.

The proposal provoked various reactions in the EU and beyond, being defined by some as 'strict' (Satariano, 2021), but criticised for being too broad and ambiguous by others (van der Wolk, 2021). In the context of the use of AIWM systems, claims have been made that the proposed regulation would fail to ensure the adequate protection of workers subject to AI-based systems. More specifically, several key limitations of the proposal have been highlighted.

- The proposal has not been subject to social dialogue, and generally lacks the voice of workers and their representatives (De Stefano, 2021; Ponce del Castillo, 2021). It does not even mention social dialogue. As such, the proposal fails to ensure the protection of workers' rights and fundamental rights (Ponce del Castillo, 2021, p. 4), and relies on technical experts in defining the regulatory framework (Ponce del Castillo, 2021, p. 6). In addition, the proposal does not include the future role of workers' representatives in regulating AI at work, which is in contradiction to many national laws across Europe that often require involving trade unions and/or work councils before introducing tools allowing any form of tech-enabled surveillance (De Stefano, 2021).

- Some others state that the absence of clear provisions attributing liability (provider vs user) and subsequent redress against the liable party is another shortcoming of the proposal (Ponce del Castillo, 2021).
- To ensure effective human oversight, supervisors in charge of AI-based systems should be ensured sufficient powers to counter decisions made by these systems. However, the proposal does not address specific workplace protection, that is, the prevention of negative consequences (disciplinary actions) for human supervisors should they choose to reverse or disregard the outputs of high-risk AI systems in the context of work (De Stefano, 2021). Given the severity of the consequences that 'AI systems at work can entail, and the particular nature of workplaces, where workers are already subject and vulnerable to their employers' extensive powers and prerogatives' (De Stefano, 2021), this should be replaced by a third-party conformity assessment in consultation with workers' representatives (Ponce del Castillo, 2021, p. 5).
- There are also limitations regarding low-risk systems as the different levels of risks they entail are not defined, allowing a free market access for multiple 'low-risk' systems without any safeguards (Ponce del Castillo, 2021).
- According to one interviewed expert, legal experts believe that the AI act will set the ceiling on AI regulation, but not the floor, meaning that national AI policies that go beyond it and are more human-centric will have to become less strict.

In addition to the European Commission, a number of EU-level organisations have also taken proactive steps to ensure the appropriate use of AI in the EU.

For example, European cross-sectoral social partners – Business Europe, SMEunited, the European Centre of Employers and Enterprises providing Public Services (CEEP) and the European Trade Union Confederation (ETUC) – signed the **European social partners' framework agreement on digitalisation**[43] in 2020. In the area of AIWM, the agreement stipulates that the deployment of AI systems should: (i) follow the human-in-control principle; (ii) be safe (that is, risk assessments should be conducted and opportunities should be undertaken to improve safety, and prevent any harm including physical integrity, psychological safety, confirmation bias or cognitive fatigue); (iii) follow the principles of fairness (that is, be free of bias and discrimination); and (iv) be transparent and explicable with effective oversight. The agreement also highlights that when AI is used in HR management (for example, recruitment, performance analysis, and evaluation, promotion or dismissal), its use needs to be transparent, and subjects should be able to request human intervention or contest the decision. Finally, the agreement notes that AI systems should comply with existing laws, including the GDPR, guaranteeing a worker's right to privacy and dignity.

The Council of Europe proposed 10 steps on how to protect human rights from a misuse of AI. To summarise, the 10 steps include (Council of Europe, 2019):

- **Human rights impact assessment** (Council of Europe, 2019, p. 7): 'Member states should establish a legal framework that sets out a procedure for public authorities to carry out human rights impact assessments (HRIAs) on AI systems acquired, developed and/or deployed by those authorities.'
- **Public consultation** (Council of Europe, 2019, p. 8): 'State use of AI systems should be governed by open procurement standards, applied in a transparently run process, in which all relevant stakeholders are invited to provide input.'
- **Obligation of Member States to facilitate the implementation of human rights standards in the private sector** (Council of Europe, 2019, p. 9): 'Member states should effectively implement the UN Guiding Principles on Business and Human Rights and the Recommendation CM/Rec(2016)3 of the Committee of Ministers to Member States on human rights and business.'
- **Information and transparency** (Council of Europe, 2019, p. 9): 'The use of an AI system in any decision-making process that has a meaningful impact on a person's human rights needs to be identifiable.'

[43] See: https://www.businesseurope.eu/publications/european-social-partners-framework-agreement-digitalisation

- **Independent oversight** (Council of Europe, 2019, p. 9): 'Member states should establish a legislative framework for independent and effective oversight over the human rights compliance of the development, deployment and use of AI systems by public authorities and private entities.'
- **Non-discrimination and equality** (Council of Europe, 2019, p. 11): 'In all circumstances, discrimination risks must be prevented and mitigated with special attention for groups that have an increased risk of their rights being disproportionately impacted by AI.'
- **Data protection and privacy** (Council of Europe, 2019, p. 11): 'The development, training, testing and use of AI systems that rely on the processing of personal data must fully secure a person's right to respect for private and family life under Article 8 of the European Convention on Human Rights, including the "right to a form of informational self-determination" in relation to their data.'
- **Freedom of expression, freedom of assembly and association, and right to work** (Council of Europe, 2019, p. 12): 'In the context of their responsibility to respect, protect and fulfil every person's human rights and fundamental freedoms, Member States should take into account the full spectrum of international human rights standards that may be engaged by the use of AI.'
- **Remedies** (Council of Europe, 2019, p. 13): 'AI systems must always remain under human control, even in circumstances where machine learning or similar techniques allow for the AI system to make decisions independently of specific human intervention.'
- **Promotion of 'AI literacy'** (Council of Europe, 2019, p. 14): 'The knowledge and understanding of AI should be promoted in government institutions, independent oversight bodies, national human rights structures, the judiciary and law enforcement, and with the general public.'

At a more global level, the OECD's Recommendations of the Council on Artificial Intelligence (2019) introduced five value-based principles for a responsible and trustworthy AI, essentially echoing the seven principles elaborated by the AI HLEG. The recommendations call for transparency and the explainability of AI used in workplaces by, among other things, (i) making stakeholders aware of their interactions with AI systems, including in the workplace, (ii) enabling those affected by an AI system to understand the outcome, and (iii) enabling those adversely affected by an AI system to contest its outcome based on plain and easy-to-understand information on the factors and the logic that served as the basis for the prediction, recommendation or decision. This is particularly relevant for workers' rights regarding automated decisions in worker management.

In conclusion, it is also noteworthy to mention the Ethics Certification Program for Autonomous and Intelligent Systems (ECPAIS)[44] created by the Institute of Electrical and Electronics Engineers (IEEE) Standards Association. It aims to create specifications for certification and marking processes that advance transparency, accountability and a reduction in algorithmic bias in Autonomous and Intelligent Systems, or AIS. Though this is still an ongoing effort; during the first phase of the programme, three AI ethics-oriented certifications were created that relate to transparency, accountability and algorithmic bias. The programme is currently testing these certifications before releasing them to the public (David et al. 2020).

Key EU-level regulations and guidelines on data governance

With the increasing deployment of AI-based tools in workplaces, questions of ethics and privacy have become especially relevant also from an OSH perspective as they are associated with potential impacts on workers' safety and health. In the EU, the most significant provisions on data protection are found in the **GDPR**[45] and **Council of Europe's Data Protection Convention 108+ (COE)**[46]. On the one hand, the **GDPR** adopted in 2016 and in force since 2018, which addresses the key issue of personal data protection and automated decision-making, is a directly applicable law in all EU Member States. The processing of personal data is at the core of AIWM, which encompasses practices of gathering worker-related data and using them to inform or automate managerial decision-making. The data protection law does not mention OSH explicitly *per se*, but since the invasion of privacy (by accessing personal

[44] See: https://standards.ieee.org/industry-connections/ecpais.html#:~:text=The%20goal%20of%20The%20 Ethics,and%20Intelligent%20Systems%20

[45] See: https://eur-lex.europa.eu/eli/reg/2016/679/oj

[46] See: https://www.europarl.europa.eu/meetdocs/2014_2019/plmrep/COMMITTEES/LIBE/DV/2018/09-10/Convention_108_EN.pdf

data) and misuse of personal data can have severe consequences on workers' mental health, provisions on data protection are essential for the discussion of AIWM and OSH. For example, Article 22 of the GDPR grants data subjects (in this context, employees or job applicants) the **right to not be subject to decisions based 'solely' on the automated processing of personal data if the decision has significant legal consequences or a 'similarly significant' effect on the data subject**, which might imply OSH-related issues. Such provision is expected to empower employees by giving them the right to demand human intervention on behalf of the data controller who could revoke or reconsider the decision made automatically by an AI system.

On the other hand**,** the **Council of Europe's Data Protection Convention 108+** (1985) is a legally binding instrument on the protection of private life and personal data, which was revised in 2018 (COE, 2018). The revision amended the *Convention for the Protection of Individuals* with regard to the automatic processing of personal data. Given that AI often automatically collects and processes data, this convention also expands on privacy-related issues that such tools might create. For example, Article 5 of Convention 108+ foresees that **personal data undergoing automatic processing** (that is, storing the data, carrying out logical and/or arithmetical operations on those data, their alteration, erasure, retrieval or dissemination) must be accurate, obtained, and processed fairly and lawfully, collected only in relevant and adequate amounts and used only for specified and legitimate purposes.

Other significant provisions in these regulations relate to the transparency of organisations, which are obliged to **provide the data subject with information about all stages of algorithmic decision-making that involve personal data** (Article 5(1)(a); Article 13; Article 14 of the GDPR; Article 5(4)(a), Article 8 and Article 9 of the revised COE Convention). According to these provisions, workers have the right to know if they are subject to automated decision-making and organisations are obliged to provide information on the logic, significance and consequences of such decision-making. This creates the so-called 'right to explanation' (Malgieri & Comande, 2017). Moreover, organisations are required to conduct systematic and extensive data protection impact assessment when the processing of personal data might pose high risks for a person's rights and freedoms (Article 25(1) of the GDPR; Article 10(2) of the COE Convention).

However, it is worth mentioning that EU data governance regulations have several significant limitations in terms of AIWM.

The regulations adopt an old-fashioned understanding of the three-phase process of data processing: acquisition, analysis, and application (Oostveen, 2016). This leads to an issue where the regulations often fail to acknowledge that personal and non-sensitive data can be used to infer, derive or predict highly intimate sensitive information, such as emotional wellbeing (Privacy International, 2017).

In addition, even though Article 22(1) of the GDPR grants individuals the right not to be subject to 'a decision based solely on automated processing' when this decision produces legal or 'similarly significant' effects (GDPR, Article 22 cited in Aloisi & Gramano, 2019, p.112), it leaves room for interpretation as to what 'significant effects' mean (Privacy International, 2017).

Furthermore, according to the independent European Article 29 Data Protection Working Party (WP29) 'significant decisions' include nudging a person via behavioural tricks and incentives (WP29, 2017. Though this clarifies some aspects, nevertheless, the GDPR provides several exceptions to this rule, some of which complicate the situation:

- Firstly, Article 22(2) of the GDPR deems decisions that are 'necessary for entering into, or performance of, a contract between the data subject and data controller' exempt from this rule. Scholars stress that a high number of decisions in a workplace fall within this category (De Stefano, 2018).
- Secondly, the GDPR states that automated-decision making can occur when it 'is based on the data subject's explicit consent.' The problem with this exception lays in the hierarchical nature of the employment relationship – 'employees are seldom in a position to freely give, refuse, or revoke consent' considering they could face adverse consequences of their non-compliant conduct (WP29 Opinion 2/2017).
- In addition, sometimes a consent clause is also included by default in the work contract forcing workers to give it if they wish to get the job. Therefore, consent is rarely a legal ground for data processing at the workplace. Additionally, considering the opaque nature of algorithms, relying

only on an explicit consent from workers seems unsuitable for AI-driven practices (Aloisi & Gramano, 2019).

For more insights on the gaps in EU regulations, see the section 4.3 Gaps and needs for actions.

Beside EU initiatives, the International Labour Office's Protection of Workers' Personal Data Code of Practice[47] (1997) stresses the importance of worker representative groups and their involvement in developing policies on workers' privacy consents. It also protects the right to not be subject to decisions based on the automated processing of data, discredits electronic monitoring and performance evaluation and automated processing, and emphasises the risk for data-based discrimination (European Parliament, 2020). The code of practice sets out the key principles in employee monitoring, particularly the right to be informed if monitoring technologies are used at the workplace, and the obligation of employers to consider any risks that might infringe on the workers' individual and collective rights by the deployment of such technologies (Eurofound, 2020b).

EU OSH directives relevant to AIWM

The main regulations related to OSH in the EU are the **EU Occupational health and safety acquis**[48] consisting of a variety of different directives, ranging from the Framework Directive[49], which is a wide-reaching directive introducing measures to encourage improvements in the safety and health of workers at work, to a variety of individual more narrowly defined directives[50]. Though the acquis are quite generic in nature and do not explicitly address AI-based systems, including ones related to AIWM, they implicitly apply to the OSH risks posed by AIWM. As such, the provisions of the Framework Directive obliging employers to conduct risk assessments, to put in place and use preventative and protective measures, to inform workers about health and safety risks, to train workers on health and safety, to engage in consultation with workers, and to exercise health monitoring also implicitly apply to AIWM.

Directive 90/270/EEC – display screen equipment[51] covers a workstation, comprised by display screen equipment and input devices, such as a keyboard, and how it should be used to ensure OSH. Article 6 of the Directive also states that 'workers shall receive information on all aspects of safety and health relating to their workstation' (p. 3). Hence, an argument can be made that if the workstation is used to collect data on workers that are then used by an AI-based system to make worker management-related decisions, which as was highlighted in this report might have negative effects on safety and health, the workers should be informed about such tools.

Similarly, *Directive 2002/14/EC – informing and consulting employees*[52] stipulates that in larger organisations[53] workers should be consulted or informed on decisions that might lead to large changes in the company. Hence, as the introduction of AI-based tools might lead to such large changes, it is necessary that employers communicate these changes to workers or, ideally, discuss them.

Nevertheless, with recent developments, such as the shift to telework, on-demand work and other working arrangements due to the COVID-19 pandemic, as well as the growing usage of AI-based technologies for worker monitoring, the directives contain several gaps that should be addressed. For a discussion on them, see the Gaps and needs for actions section.

Regulation on equality and non-discrimination relevant to AIWM and OSH

It is crucial that the dignity, humanity and fundamental rights of individuals are not in any way violated by AIWM tools. EU legislation that, to some extent, ensures this is the **EU Charter of Fundamental Rights**, **European non-discrimination law**, the **European Convention on Human Rights**, and the

[47] See: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/normative_instrument/wcms_107797.pdf
[48] See: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A31989L0391
[49] See: https://osha.europa.eu/en/legislation/directives/the-osh-framework-directive/1
[50] See: https://osha.europa.eu/en/safety-and-health-legislation/european-directives
[51] See: https://osha.europa.eu/en/legislation/directives/5
[52] See: https://osha.europa.eu/en/legislation/directives/directive-2002-14-ec-establishing-a-general-framework-for-informing-and-consulting-employees-in-the-european-community
[53] The directive applies to organisations with 50 employees across several EU countries or 20 employees in one Member State.

General Framework for Equal treatment in employment and occupation, based on Directives 2000/43/EC, 2000/78/EC and 2002/54/EC[54]. These directives ensure that human rights are kept to the highest standards in the EU and prohibit any direct or indirect discrimination based on religion, disability, age, sexual orientation and other grounds. The General Framework for Equal treatment in employment and occupation also prohibits discrimination that might hinder access to employment, and self-employment, through discrimination in recruitment, access to vocational training and similar, as well as any discrimination in terms of pay and similar. In addition, according to interviewed experts, discrimination based on trade union affiliation is also often legally protected in the EU. Hence, it can be inferred that, on paper, these legislations protect workers in case of discriminatory semi- or fully automated decision-making in workplaces. However, it is often difficult to protect workers from discrimination and even to prove that it happened in the first place, as is discussed in the section 4.3 Gaps and needs for actions.

4.2 National regulatory context and initiatives in the EU Member States

Given that, in the context of this report, it is impossible to cover the entire regulatory context and all of the initiatives in EU Member States, only the ones that can be considered the most important for the purposes of this research are covered in this section.

National strategies on AI

Following the EU's Coordinated Plan on Artificial Intelligence, some EU Member States also started to adopt AI-related strategies. According to JRC-OECD (2021), by June 2021, 20 EU Member States[55] as well as Norway and Switzerland have adopted at least some AI-related strategies, while the remaining Member States are in the final drafting phases. In broad strokes, these strategies define national policy frameworks on AI in five areas: (i) human capital, (ii) R&D and innovation, (iii) networking and collaboration, (iv) infrastructure, and (v) regulation. These key building blocks set the course of action for the public and private sectors in testing and experimenting with AI for business growth, building relevant digital and telecommunication infrastructures, and boosting AI potential at the national level through international as well as public-private sector cooperation as well as skill enhancement, up-skilling, and reskilling of the current and future labour force (JRC-OECD, 2021).

These strategies do not explicitly target AIWM or OSH. However, a few of them do consider the potential impact AI might have on workers and work, for example:

- The **German Federal Government's Artificial Intelligence Strategy** (2018)[56] includes a provision to establish an AI observatory to draw up joint guidelines and frameworks, together with data protection authorities and business associations, specifically for the use of AI in the world of work. The strategy also highlights the need to audit organisations on their use of AI (that is, setting benchmarks for employment, technical design, human-machine interfaces, health and safety, and data protection). Initiating a European and transatlantic dialogue on the human-centric use of AI in the world of work is also among the strategic actions. The strategy also points to several legislative changes to empower workers, such as ensuring co-determination and the right for work councils to be involved in the processes of introducing and using AI at the workplace. Amendments of relevant legislation are also foreseen to ensure that the already existing right to co-determine the selection criteria used for recruiting, re-assigning, promoting/demoting and laying off workers would also apply when AI is used.
- The **French national AI strategy**[57] points to two key actions relevant to AIWM and OSH, according to Villani (2018). First, it encourages the inclusion of workers as the *subjects* of digital transformation into *ex ante* discussions regarding AI usage in workplaces. The existing

[54] Council Directive 2000/43/EC of 29 June 2000 implementing the principle of equal treatment between persons irrespective of racial or ethnic origin; Council Directive 2000/78/EC of 27 November 2000 establishing a general framework for equal treatment in employment and occupation; Directive 2006/54/EC of the European Parliament and of the Council of 5 July 2006 on the implementation of the principle of equal opportunities and equal treatment of men and women in matters of employment and occupation.

[55] Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain and Sweden.

[56] See: https://knowledge4policy.ec.europa.eu/publication/germany-artificial-intelligence-strategy_en

[57] See: https://www.aiforhumanity.fr/pdfs/MissionVillani_Report_ENG-VF.pdf

compulsory collective bargaining is proposed to factor in the introduction of new technology and the digital transformation of companies and serve as a forum for such discussions. Second, the strategy urges for the launch of legislative reform to adjust the overall framework for governing working conditions in the digital age with a specific focus on increasing human-machine complementarity (for example, prevention of exclusive following of a machine's instructions, the possibility of a discussion with colleagues without going through a machine interface). The strategy also makes references to the potential benefits of AI use in worker management, such as the potential use of AI to monitor and reduce discrimination and gender inequality in the workplaces.

- The **Czech national AI strategy**[58] (Ministry of Industry and Trade of the Czech Republic, 2019), in addition to other provisions, lays down measures to address the impact of AI on the labour market and the social system.
- In **Spain** the so-called **Riders' Law** aims to establish the employment status of riders and algorithm transparency (Aranguiz, 2021), which might also be relevant for other occupations. The law makes it mandatory for digital platform companies to be transparent about how the algorithms and AI they use affect working conditions as well as profiling, hiring and lay-off decisions (Pérez del Prado, 2021).

From outside the EU, **Norway** also has a national strategy for AI that contains some elements implicitly relevant for worker management and AIWM (Norwegian Government Security and Service Organisation, n.d.). The strategy includes a belief that AI in Norway should be built following ethical principles, while its research, development and use should foster a responsible and trustworthy AI. The development and use of AI in Norway should also foster the integrity and privacy of individuals. Similar to the GDPR, according to this strategy individuals should have the ability to opt out from being subjected to automated decision-making that might significantly affect them. These are only some aspects of how AI should be used that are mentioned in this strategy. Nevertheless, the state does not explicitly mention workers or employers.

National regulations relevant for OSH in relation to AIWM

All EU countries have general OSH regulations in place implementing the EU OSH Framework Directive, which, while not explicitly addressing the adoption of advanced digital technologies in workplaces, require employers to ensure workers' safety and health. In a similar regard, the labour laws in all countries grant workers various rights and define their working conditions (for example, working time, provisions on workplace surveillance and monitoring), which are relevant when discussing AIWM and OSH. One example of such a regulation is the El Khomri Law in France, granting workers the 'right to disconnect', which allows workers to completely disconnect from work after working hours (Kessler, 2016). A 'right to disconnect' is also part of the Spanish law on data protection, yet, contrary to France, the law does not impose sanctions on employers (Brin, 2019). In other countries – Belgium, Luxembourg and the Netherlands – these questions were also put forth on the policy agenda, but to this date remain only at a debate level (Govaert et al., 2021).

Relevant national codes of practice and guidelines

Efforts by national authorities and social partners were also made to introduce codes of practices and guidelines to ensure the just and ethical use of AI, which is also relevant for AIWM. A few notable examples identified through consultations with EU-OSHA FOPs carried out between February and April 2021 include:

- **A concept paper on how to deploy and use AI in business in Germany**[59]**.** Developed by the German Trade Union Confederation (DGB), the concept paper, titled 'AI for Good Work', published in 2020, outlines a six-step process for the deployment of trustworthy AI in workplaces, each containing a set of crucial questions to be asked before the process (DGB, 2020). The paper also addresses the importance of worker involvement when adopting AI in workplaces. It stresses the need to institutionalise co-determination for the entire process chain.

[58] See: https://www.mpo.cz/assets/en/guidepost/for-the-media/press-releases/2019/5/NAIS_eng_web.pdf
[59] See: https://www.dgb.de/downloadcenter/++co++b794879a-9f2e-11ea-a8e8-52540088cada

It specifically highlights that co-determination should be extended to usage forms of data and techniques to minimise risks associated with the processing of personal data.

- **Operational indications on the installation and use of support tools, including AI-based ones, in call centres in Italy**[60]**.** Drafted by the Italian National Labour Inspectorate, the document covers various tools and software applications that can be used to manage workers. For example, so-called client relationship management, or CRM, software allows for collecting and coupling information between a customer's and an operator's data, and therefore goes beyond the contractual relationship between employer and operator. Other software referred to in the guidelines is that aimed at monitoring and collecting data on the operator's telephone activity 'almost in real time'; the ones used to monitor operators' productivity that allow for collecting and quantifying data on time spent per call and individual breaks, for example. The guidelines also refer to the use of audiovisual and other systems and the risk of remote worker control. The use of this software also gives disproportionate power of control to employers over workers (Circolare N.4/2017). The instructions also deem any software that enables a constant and continuous individualised monitoring of workers as not necessary to perform work-related activities. Therefore, its use should be subject to an agreement with trade unions and should be authorised by law.
- **Guidelines on worker monitoring in Cyprus**[61]**.** The Commissioner for Personal Data Protection in Cyprus has published guidelines relating to the use of software for monitoring employees' computer activities. According to the guidelines, under specific circumstances and in compliance with a specific regulation, employers can monitor some computer activities, but the monitoring of all activities or private email correspondence is prohibited (Eurofound, 2020b).

From outside the EU, **Switzerland**, one of the EFTA countries, also has AI guidelines for the federal administration[62]. Created in 2019 by the interdepartmental working group on AI (Arbeitsgruppe künstliche Intelligenz, IDAG KI), Federal Department for the Environment, Transport, Energy and Communication (DETEC), and Federal Department of Economics, Education, and Research (EAER), they provide an orientation framework on the use of AI to the federal administration (The Federal Council of Switzerland, 2020). Though not explicitly targeting AIWM, the guidelines nevertheless touch upon it. For example, there is a provision that AI-based decision-making processes should be designed in such a way that they are verifiable and traceable. The guidelines also address responsibility and liability, security, co-governance and a human-centred approach to AI systems, all of which are relevant to the use of AI in workplaces.

Stakeholder debates

The results of the consultation with EU-OSHA FOPs carried out between February and April 2021 show that debates on the AIWM effects on OSH are taking off across most EU Member States. For example, on the one hand, the **Visegrád Group countries** (Czech Republic, Hungary, Poland and Slovakia) issued a joint statement in which the signatories choose to evaluate the benefits and possible risks associated with the development of AI-based technologies, including at work. They also point to the potential for the development of European businesses based on AI, but at the same time indicate the need for an in-depth analysis of legal, economic and social implications. In the statement, some ways in which this can be achieved are also proposed, such as creating a virtual data warehouse or establishing an AI observatory at the EU level.

Also in **Poland**, a variety of debates on AI were held, such as the one on the Future of Work, which was held by the Polish Parliamentary Group and covered the possible impact of robotisation and AI on work, as well as supervision of employees in digital companies (Wawrzyniak & Zygmuntowski, 2020). Trade unions also raised concerns regarding the negative effects that AI tools might bring, proposing to introduce anti-discrimination and control mechanisms for the use of algorithms in worker management and to provide the Polish State Labour Inspectorate with the necessary instruments to control automated decision-making processes in labour relations. One of the trade unions also proposed that questions related to algorithms that manage workers be included in collective agreements

[60] See: https://www.ispettorato.gov.it/it-it/orientamentiispettivi/Documents/Circolari/INL-circolare-4-2017-call-center-e-videosorveglianza.pdf
[61] See Eurofound (2020b) for an overview.
[62] See: https://www.sbfi.admin.ch/sbfi/de/home/aktuell/medienmitteilungen/news-anzeige-nsb.msg-id-81319.html

or work regulations[63]. In addition, according to Poland's FOP, a heated debate also started when a Polish ombudsman questioned the legality of a tool that evaluated whether consultants in a bank were smiling enough during conversations with customers. According to the ombudsman, the practices that forced workers to constantly smile should be regarded as intrusive into the privacy and dignity of an individual as it might imply a change in an employee's natural characteristics and behaviour. However, after an investigation by the Chief Labour Inspector it was deemed that this tool does not violate the Labour Code because it was voluntary.

While there has been some discussion concerning whether there should be special laws in **Finland** targeting AIWM, the general opinion is that the issue is already covered in other, more general laws. However, there are several debates in Finland focusing on the capabilities of AI, for example, whether AI should only be used to collect and summarise data or if it may also learn to make good and reliable decisions autonomously. In addition, while the COVID-19 pandemic did not spark a debate on AIWM systems, there were some discussions on the management of remote workers, and especially its challenges, how to keep up a sense of belonging to the work community, and what this means for management practices.

While there have not been any debates on AIWM in **Croatia**, several events regarding digitalisation and AI took place in recent years. The events were organised and attended by various stakeholders, including employer and worker representatives, academia, politicians and various organisations. During these events topics related to AI, robotics, and informatics in the field of OSH were covered.

In addition, in **Germany**, the debated aspects of AI at work include data protection, ethical issues, human- and user-centric use, and the regulation and certification of AI applications. Similarly, in **Austria**, questions such as data protection, worker participation as well as AI impact on health are discussed. In **Italy**, AIWM and its accompanying risks are starting to be debated among different stakeholders and at various levels, including technical, cultural, governmental and work levels, among trade unions. Finally, in **France**, the discussions related to AI are mainly focused on the topics of human-machine interface, data protection and the right to disconnect. In addition, French national strategy defines the role of workers and their representatives in the design and use of AIWM-type systems in workplaces.

On the employers' side, 17 business organisations and internet platforms from nine EU countries[64] recently issued a joint position on AI, stating that an awareness of the negative aspects of AI should not lead to banning its use, for example, in face recognition technology. Businesses called for a dialogue between politicians, professionals, businesses and civil society institutions on the responsible development and application of AI[65]. They stressed that, while respecting personal data and protecting privacy, AI has a positive impact on different areas of life, and thus there is no need for excessive and unnecessary legal regulation.

In addition, several FOP representatives suggested that the topic of AIWM might appear on the discussion table as a result of the COVID-19 pandemic later on. More specifically, the future agenda of social dialogue and collective bargaining is likely to involve questions on the management of remote workers or the use of new technologies to ensure that workers have a safe working environment.

4.3 Gaps and needs for actions

This section discusses regulatory and other gaps and needs, as well as potential ways to mitigate the effects of the development and use of AIWM systems on OSH. Although the present report has not developed a detailed analysis of the challenges and risks that AI-based forms of worker management may have on OSH, the literature review and interviews with experts as well as consultation with EU-OSHA's FOPs help to distil several insights on needs and gaps within the current regulatory framework. The remainder of the section goes into depth into each gap and need.

[63] See the All-Poland Alliance of Trade Unions (OPZZ) statement: https://www.opzz.org.pl/aktualnosci/kraj/kto-ma-algorytmy-ten-rzadzi-swiatem
[64] Bulgaria, Czech Republic, Croatia, Lithuania, Hungary, Poland, Romania, Slovenia and Slovakia.
[65] See: http://konfederacjalewiatan.pl/aktualnosci/2020/1/wspolne_stanowisko_biznesu_w_sprawie_sztucznej_inteligencji

Design, development and use of AI-based systems

One extensively discussed issue is that **AIWM systems might foster discrimination and bias** (see the subsection Risks of the application of AIWM for a more in-depth discussion), which current existing EU regulations might fail to protect against (Borgesius, 2020). For example, according to a judgement of the European Court of Human Rights (ECHR), in one case a victim must prove that a decision or practice that appears neutral actually disproportionately affects a protected class and is discriminatory (ECHR, 2007). This is an important issue, especially given that workers, and often managers, do not have the tools and knowledge to truly understand how such tools operate (Fernandez & Gallardo-Gallardo, 2020) and, hence, when they are discriminatory. Laws are even less effective when discrimination is indirect, considering that indirect discrimination is much more difficult to detect and prove (ECHR, 2016). Furthermore, even if a discriminatory activity can be proven, there is still the dilemma of accountability as it is unclear who exactly should be accountable for an action performed by AI (see the Barriers and risks subsection for more).

To mitigate any possible discrimination, and many other issues including OSH risks discussed in the Risks of the application of AIWM subsection, **worker inclusion should be ensured in the design and risk assessment, and periodical reassessment, of AI and algorithmic systems as well as in the decisions** taken using AI and algorithmic systems. Algorithms should be designed in a way that take into account potential social implications, such as the characteristics of the targeted data subjects (that is, workers) like ethnicity, race, gender, socioeconomic status and other demographic characteristics (ETUI, 2020).

This can be guaranteed by ensuring the **co-governance of AI-based systems**, including in the design, development, usage (including decision-making processes based on AI) and assessment of the risks and impacts of AI and algorithmic systems on individuals and groups, including on human rights, workers' rights and legal compliance (such as with anti-discrimination laws) (Colclough, 2020). Co-governance might furthermore help to put in practice the EU AI HLEG recommendation of keeping a human-in-the-loop principle, but still leave the responsibility for these systems to managers (European Commission, 2020; AI HLEG, 2019b). Inspiration can be drawn from the Medical Devices Regulations (EU 2017/745 and EU 2017/746) that include measures on *ex ante* safety assessments, the capacity of oversight (algorithms), reinforcement of the responsibility of manufacturers, importers and other actors involved in marketing, and articles concerning the anticipation and monitoring of potential unintended uses/misuses. Workers' representatives could also contribute to the development of industry- or sector-specific standards (guidelines, criticality standards) for AI applications and their use in workplaces.

Expanding on this, several interviewed experts (academics and social partners) also pointed to the need for a **holistic approach in designing and assessing algorithms**. In their opinion, the current *ex ante* and *ex post* risk assessments of these systems are only done at an engineering level. Therefore, there is a need to include different experts (for example, sociologists, OSH experts) in the process of designing and assessing the risks of algorithmic or AI-based systems. It is also important to ensure that the assessment does not evaluate AI-based systems in a vacuum, but also takes into account how such systems impact workers and their health, safety and wellbeing, as well as society as a whole. Similarly, according to Colclough (2020), trade unions could negotiate various phases of the 'data life cycle at work' and secure the co-governance of data-generating and data-driven algorithmic systems. All in all, based on the conducted interviews and the literature review, there seems to be a consensus that **the voice of workers matters when creating and deploying AIWM tools**.

It is worth mentioning that the OSH Framework Directive (Directive 89/391/EEC) already includes a provision for workers' consultation in relation to the introduction of any new technology, system and work process, as well as for workers' participation in the workplace risk assessment, all of which implicitly apply to AIWM. Therefore, as per OSH legislation, to some extent, co-governance is an obligation. Similarly, as was discussed, at the EU and national levels there are many other regulations that should prevent employers from abusing and misusing AI-based systems, including AIWM. For example, GDPR Articles 13-15 on transparency and Article 35 on data protection impact assessment mention including a representative sample of employees when such an impact assessment is carried out[66]. However, according to Colclough (2020), very few unions or worker representatives are involved

[66] See: https://gdpr-info.eu/art-35-gdpr/

in discussing questions related to data protection and impact assessment. In addition, according to other sources (for example, McCann FitzGerald, 2021; REaD Group, 2021; Ruohonen & Hjerppe, 2021), many organisations still fail to comply with the GDPR. This might indicate issues with regulation enforcement, which is discussed further in subsequent sections.

Besides this, **there is also a need to clarify the responsibilities and liabilities of developers and managers in relation to the design, development and use of AIWM systems and their potential negative effects on OSH**. More specifically, and with regard to the certain level of decision-making autonomy of AI systems, it is **crucial to have liability clauses** introduced that establish who is to take responsibility for a mistake by AI that leads to a negative consequence (for example, developers, managers who implemented/use the tool, company owners). According to the European Trade Union Institute (ETUI), a (mandatory) framework to assess AI risks specifically in the context of work relations would help to clarify the liability of employers and developers by taking into account the different dimensions of AI systems (that is, physical, behavioural, biological, emotional and neurological) and workers' exposure to these dimensions (Ponce del Castillo, 2021, p. 7). In addition, **standardised certification procedures for AI providers and developers should be developed** to ensure that any AI used in the EU is human-centric, transparent and trustworthy (DGB, 2020). Finally, **financial incentives should support the creation of 'AI for good'**. One expert highlighted the issue that public bodies are often playing 'catch up' with multi-billion euro companies that are at the forefront of AI development and usage. Hence, to level the playing field a bit, financial support should be provided to public and completely transparent projects that try to create AI systems that do not aim at improving productivity and efficiency for business but at improving OSH. Financial incentives could also be used to stimulate technological business strategies on the condition that the integration of AI-based systems into the workplace be subject to social dialogue and are for the general good (De Stefano, 2018).

Workers' privacy and data protection

AIWM raises concerns about data protection, as sometimes employers collect data that are far beyond necessary and even legal (EU-OSHA, 2020a). In addition, workers often lack knowledge about the systems in place, especially what data are being used and for what purposes. For example, workers may not know what metrics are used to determine their salary or work schedule (Pakes, 2020). This not only potentially violates their privacy, it also prevents them from contributing to OSH management in the workplace. Hence, in the context of rapidly progressing management practices, it is important to reconcile the competing interests of the employers' need for information with the workers' need for privacy and respect for OSH rights. Some of these needs are the following:

- **Worker's consent.** There is an obligation to have a worker's free consent to collect data about them as per the GDPR. However, in practice, workers still have difficulties in exercising their rights, such as to be informed, gain access, seek rectification or erasure or to restrict processing and data portability; to object and/or to ask for the logic behind automated decision-making and profiling (Ponce del Castillo, 2021, p. 7). Therefore, an informed worker's consent should become the obligation of an employer specifically in terms of processing worker-related data (Ponce del Castillo, 2021, p. 7). In addition, since workers might be afraid of negative repercussions from employers if they do not give consent, the 'freedom' element of consent here becomes dubious. In that regard, EU- or national-level regulations could include additional provisions prohibiting lay-offs or any other negative actions due to a worker's refusal to give consent to collect data about them. Though this solution does not completely solve the problem as it would be legally difficult, according to the Working Party on GDPR Article 29 (WP29, 2017) for workers to prove that they were laid off for not giving consent, it still could be a step in a right direction. Hence, an alternative approach proposed by one expert during an interview was that instead of focusing on consent, the focus should be on the better enforcement of Articles 13-15 of the GDPR, which are predominantly about the transparent usage of personal data. They include stipulations allowing workers to get information for what purpose the data were collected (Article 13(1)(c) and Article 14(1)(c)) that give tools for individuals to lodge a complaint regarding how the data are processed to supervisory authorities (Article 13(2)(e) and Article 14(2)(e)), receive information on how the privacy of the data is safeguarded when the data is transferred to third parties (Article 15(2)), and more.

- **Purpose and type of data collected on workers.** Data collected on workers should have strict limitations as in what circumstances and for what purposes they could be used. Employers should be bound by a 'purpose limitation' of these data to ensure that they are not used and reused (or even sold) for purposes other than what they were collected for (Ponce del Castillo, 2021, p. 7). While this principle is ensured by Article 5(1)(b) of the GDPR, it does not refer to data collected on workers specifically and thus, as mentioned above, workers could have difficulties in exercising their data-related rights. Hence, for this article to be useful for workers, it is important to ensure a strong enforcement of the transparency requirements covered in the GDPR and other regulations. No less important is the type of data collected. Enabled by AI, worker surveillance and possibly also management are now based on very advanced analytics that are able to measure human biology, behaviours and moods (Ponce del Castillo, 2021, p. 8). This kind of surveillance technology 'scrapes the personal lives of workers, actively builds an image and then makes decisions' (Ponce del Castillo, 2021, p. 8). Intrusive as it is, this kind of digital worker surveillance should be prohibited as a threat to fundamental human rights and a potential catalyst of negative OSH effects.
- AIWM systems may accentuate hierarchies and introduce new forms of (potentially oppressive) monitoring at workplaces and surveillance outside of workplaces and working hours. For example, monitoring employees not only makes it possible for employers to track employees' locations and determine their daily routines, but also to obtain private information, for example, on health (ETUC, 2021). The **right to disconnect** previously discussed (see the subsection National regulations relevant for OSH in relation to AIWM) that is a law in France (ETUI, 2020) is an important step against such practices. In addition to its primary goal of guaranteeing workers the right to disconnect from work during non-working hours, it could also serve as a means to ensure workers' privacy and personal data protection, in particular when it is related to disproportionate, not strictly necessary monitoring and surveillance. **Better reporting mechanisms on misuses of AIWM tools** – given that workers might fear to report on some cases of misuses, the EU could set up robust reporting mechanisms that might include reporting to public authorities such as the national data protection authorities (NDPAs) or other supervisory authorities. These mechanisms could also include whistleblowing systems.
- **Enhanced labour inspector capacities and cooperation with NDPAs.** To fulfil the obligations of the GDPR and the duty of inspection as stipulated in GDPR Articles 77 and 78[67], enhanced cooperation between labour inspectors and GDPR supervisory authorities could be considered. Capacities could also be further enhanced by providing more funding to relevant authorities as well as training to ensure that labour inspectors are well equipped to evaluate the negative consequences that AIWM might bring (for more on improving AI literacy, see the next subsection).
- **There is a need to ensure that workers know how to exercise their privacy rights.** Though Article 88 of the GDPR already provides some provisions regarding this[68], they might be insufficient. Namely, new provisions are needed to respond to demands from workers about access to their collected and analysed data and how such data are used, stored or shared outside of the employment relationship. Additionally, trade unions at the national level should be empowered to cooperate with national data protection authorities, provide them with advice about the specific situations of workers, and encourage them to develop specific guidelines on data protection and privacy at the workplace. It is also important to note that although Article 88 of the GDPR provides some relevant provisions, some interviewed experts mentioned that the new European Commission proposal on regulating AI would go against them by 'preventing national measures providing specific labour and employment safeguards' (De Stefano & Aloisi, 2021, para. 14).
- **Provide information to individuals and workers on AI-based systems that make inferences on them that do not directly use their personal data.** According to Wachter and Mittelstadt (2018), many existing AI-based systems, which implicitly include AIWM, are able to

[67] See: https://gdpr-info.eu/art-78-gdpr/; https://gdpr-info.eu/art-79-gdpr/
[68] See: https://gdpr-info.eu/art-88-gdpr/

make inferences on individuals without explicitly using their private data. For example, based on historical data, an algorithm might deem someone not fit to perform a particular task at work based on the individual's gender, race, age and similar, and hence will not even offer it to them. This, in turn, leads to discrimination and takes away some autonomy from workers. Because of this, Wachter and Mittelstadt (2018) and some interviewed experts agree that there is a need to ensure that regulations are expanded to also include stipulations that ensure transparent inferential decision-making.

AI literacy, right to explanation and balance of powers

Potentially, the use of AI-based systems in workplaces can also result in the abuse of managerial power stemming from the nature of the employment relationship (Ponce del Castillo, 2021). Therefore, **the regulatory framework should ensure that the impact of AI applications on workers is evaluated**. More specifically, workers and their representatives should be actively involved in the process of assessing potential AI risks and impacts in the context of employment (Ponce del Castillo, 2021). It is also important to ensure that this assessment be done not only once, but that it is periodically repeated given the ever-evolving nature of AI systems that are able to self-learn. However, as was already mentioned , including in relation to the GDPR, this is sometimes lacking. Hence, the need for a **strong enforcement** of existing, as well as potential future, regulations should be guaranteed.

In addition, the '**right to explanation**' for decisions made by algorithms or machine learning models should be ensured. Decisions made by algorithms can be based on incorrect assessments or have different biases stemming from the design, data, infrastructure or misuse of the model. Building on Articles 13-15[69] and Recital 71[70] of the GDPR, mechanisms and frameworks should be created so that workers can exercise this right. In practice, this means obtaining information that is simultaneously understandable, meaningful and actionable (GDPR, Article 12[71]), and makes it possible to: (a) understand the significance and consequences of an automated decision; (b) obtain an explanation for an automated decision; and (c) challenge the decision. In sum, the complexity of AI systems should not be an excuse to undermine workers' rights (ETUI, 2020).

Employers should guarantee full **algorithmic workplace explainability** by providing workers with an 'understanding of how an algorithm has pushed, nudged or influenced matters in a certain direction and not simply a description of its inner workings' (Ponce del Castillo, 2021, p. 7). This, according to Ponce del Castillo (2021), is essential in workplaces where workers interact with AI directly so that they understand the role and impact of AI instead of being no more than data points or receivers. Inspiration can be drawn from the pioneering **Riders' Law** adopted on 11 May 2021 in Spain, which came into force on 10 August 2021 and introduced for the first time at national regulatory level the right to algorithmic transparency, forcing every type of platform (not limited to delivery platforms) to **inform the (platform) workers' legal representatives about the inner functioning of the algorithms** 'that may affect working conditions, and access to and maintenance of employment, including profiling' (Article 64.4. of the Workers' Statute[72]) (EU-OSHA, 2022c). The rights of workers to algorithmic/AI transparency could be replicated and transferred to other organisations outside of the platform economy, granting workers and their representatives, access to and full transparency of algorithms/AI used in the workplace and the rationale behind their decision-making. However, a further step forward in terms of regulation would be to make the human-in-command principle mandatory in all human-machine interactions, to ensure that workers' representatives play an active part in estimating the need for a human operator and that humans – not algorithms – are given final decision-making power (Ponce del Castillo, 2021, p. 8). It is important to note that the current European Commission proposal on regulating AI[73] does include mandatory human oversight but only for those AI systems labelled as high-risk (see Article 14 of the proposal). As such, it does not foresee a mandatory human-in-command principle for other, low-risk human-machine interactions and does not ensure the involvement of workers'

[69] See: https://gdpr-info.eu/art-13-gdpr/; https://gdpr-info.eu/art-14-gdpr/; https://gdpr-info.eu/art-15-gdpr/
[70] See: https://gdpr-info.eu/recitals/no-71/
[71] See: https://gdpr-info.eu/art-12-gdpr/
[72] The new Workers' Statute was introduced by the *Real Decreto Legislativo 2/2015, de 23 de octubre* (Royal Decree Law 2/2015, of 23 October).
[73] See: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1623335154975&uri=CELEX%3A52021PC0206

representatives. Workers should also be granted the right to edit or block algorithmic inferences (Colclough, 2020); this is also not included in the European Commission's proposal.

Finally, there is a **need for the reskilling and upskilling of workers, including HR managers, to allow them to better understand the workings of AIWM**. Likewise, during the FOP consultations, many respondents stressed the need to improve the knowledge level of policy-makers and stakeholders as currently only a very small fraction of them truly understand AI. In addition to focusing on AIWM, education efforts should also cover the possible risks and challenges AIWM might create for OSH, as well as providing education on the existing legal provisions related to AI systems, OSH, data protection, and other relevant aspects such as anti-discrimination and fundamental rights. Such education efforts could contribute to the ability to contest algorithmic decisions that might lead to negative OSH effects.

Better addressing AIWM systems in OSH regulations

Horizontal and sectoral rules need to be reviewed in order to identify any OSH risks arising from the use of AI in managing workers as well as to protect and ensure benefits from the integration of AIWM. The EU's Occupational Health and Safety acquis ensures some general provisions that are applicable to AIWM, but more specific regulation would be needed to ensure workplace safety and health arising from the introduction of new forms of worker management.

Some of the interviewed experts suggested that **more AI-based worker management-centric articles could be added to complement the EU Occupational Health and Safety acquis**. For example, though the EU Occupational Health and Safety acquis extensively cover OSH, there are no legal provisions that specifically address the health and safety risks of the use of algorithms for decision-making in the workplace. This makes answering certain legal questions difficult – for example, who should take responsibility when a machine makes a fully automated decision that negatively affects a worker's health, safety or wellbeing? In that regard, one interviewed academic expert suggested adding a chapter on algorithmic/AIWM in, for example, the Display Screen Equipment Directive (90/270/EEC) as this might mitigate the issue. According to the expert, it could at least explicitly include the requirement to consult workers and/or their representatives about the use of AI-based systems for worker management. Some inspiration for this can also be taken from a bill that the state of California (United States) recently passed that tries to mitigate the negative effects that algorithmic-driven rules can create. The California Assembly Bill 701[74] entered into force on 1 January 2022 – defines a 'quota' to refer to

> *'a work standard under which an employee is assigned or required to perform at a specified productivity speed, or perform a quantified number of tasks, or to handle or produce a quantified amount of material, within a defined time period and under which the employee may suffer an adverse employment action if they fail to complete the performance standard.'*

Employers must provide to each of their employees at the moment of being hired a written description of each quota that applies to them, and the 'quantified number of tasks to be performed or materials to be produced or handled, within the defined timer period, and any potential adverse employment action that could result from failure to meet the quota.' The law establishes that employees shall not be required to meet quotas that prevent them from taking compliant meal and rest periods, restrict use of bathroom facilities (including reasonable travel time to and from the bathroom), or violate OSH laws. Employers who do not comply can be prosecuted and are subject to penalties[75].

Another point would be to **explicitly address the impacts on OSH of the different AI systems and their applications, including AIWM**. According to the DGB (2020), a broad spectrum of AI systems used in workplaces suggests that the applications' modes of action could be divided into different levels of criticality; for example, it is speculated that individual profiling tools would not create the same negative impact on mental health as some other monitoring and surveillance tools. Hence, it is suggested that there could be explicit assessments of mental health issues that might have been brought about by the introduction of AI tools (DGB, 2020). To some extent, this is already included in the Proposal for a Regulation on a European Approach for Artificial Intelligence[76] under high-risk

[74] For more, see: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB701
[75] See: https://www.californiaemploymentlawreport.com/2021/09/california-passes-law-regulating-quotas-in-warehouses-what-employers-need-to-know-about-ab-701/
[76] See: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1623335154975&uri=CELEX%3A52021PC0206

systems. However, the discussion in this proposal is relatively general and predominantly focuses on AI tools with large sweeping effects on work such as recruitment and worker firing and ignores the possible negative effects on OSH that ‘simpler’ AI tools might create (for example, aggressive AI-powered scheduling tools leading to fatigue and stress in workers). Hence, this provision could be further expanded upon by establishing more direct links between the different types of AI tools and how they impact OSH.

There is also concern that the **narrow definition of ‘workplace’** in the EU legislation fails to properly address new ways of working. The definition of ‘workplace’ in Article 2 of the Workplace Directive reads as follows: ‘the place intended to house workstations on the premises of the undertaking and/or establishment and any other place within the area of the undertaking and/or establishment to which the worker has access in the course of his employment.’ [77]This same definition is also found in many other OSH directives. The issue with this narrow definition is that some workplaces, such as those enabled by telework, are not covered (Cabrelli & Graveling/European Parliament, 2019), which also leads to some invasive AI-based systems not being covered.

To mitigate these issues, in general, the literature highlights the need for more regulations, which is supported by a significant number of interviewed experts. For example, one interviewed employers’ representative claimed that risks and measures to mitigate issues are only starting to be taken into account in regulations, referencing the GDPR as an example. Several interviewed academics with expertise in AI also expressed a pro-regulation position, noting the numerous OSH risks that AI systems pose to workers (for example, stress, depression, intensification of work, loss of job control and ‘turning workers into robots’). Similarly, the literature discussed to this point predominantly talks for more and better regulation (for example, see High-Level Expert Group on Artificial Intelligence, 2019b; Eurofound, 2020b; EU-OSHA, 2019; Ponce del Castillo, 2021).

However, it bears mentioning that not everyone agrees that more regulations are the way to go forward. For example, several experts from academia, social partners and representatives of EU organisations claimed that current laws, at least at the EU level, are sufficient to ensure the safe and ethical deployment of AI-based systems in workplaces and to mitigate potential OSH risks. One expert from academia with a background in law also claimed that AI-based systems are a wide-ranging phenomenon. Therefore, they stipulated that **the best way to regulate is to apply the already existing regulation with regard to the purpose of the tools/systems used**. For example, if the tool is being used to hire workers, then the anti-discrimination law could be applied; if tools are being used to organise tasks at work, then the existing OSH law could be applied; and if AI tools are used to collect data for performance evaluations, then the data protection laws could be applied. The same expert also acknowledged that for the time being, society is at the centre of the transformation, witnessing the application and expansion of managerial prerogatives over employees with the help of AI. For this reason, there is a lot of experimenting going on and companies that apply these new tools for employee management, as well as workers themselves, are serving as guinea pigs. Hence, given that it takes time for new regulatory proposals to become laws, it might be more productive to focus on improving enforcement of the existing ones.

[77] See: https://osha.europa.eu/es/legislation/directives/2

5 Conclusions and recommendations

AIWM is an umbrella term that refers to a **worker management system that gathers data, often in real time, from the workspace, workers and the work they do, which are then fed into an AI-based system that makes automated or semi-automated decisions, or provides information for decision-makers (for example, HR managers, employers, workers), on worker management-related questions**.

Organisations implement AIWM systems to reach certain business objectives, such as increasing efficiency and productivity. AIWM involves a number of practices, including, but not limited to, **enhancing worker monitoring/surveillance** through, for example, performance monitoring, **introducing AI-powered automatic scheduling systems** to automatically allocate tasks to workers, or **introducing people analytics systems** in order to, for example, evaluate worker engagement or predict who is likely to leave the organisation. In addition, AIWM systems can also help with worker health, safety and overall wellbeing, if they are implemented in a safe, trustworthy, transparent and ethical way. For example, AIWM can be used to **identify risks to workers' health, safety and/or wellbeing** through monitoring systems that can identity instances of, for example, workplace bullying through, for example, speech analysis.

Although the current uptake of AIWM is relatively low across the EU, its usage is steadily growing according to the literature and expert interviews. However, it has to be mentioned that there is a lack of data capturing the uptake of AIWM systems and even less on their effects on OSH and, hence, any insights can only be derived inferentially from proxies, such as the use of technologies that can enable AIWM systems. According to weighted ESENER-3 data, in 2019 only 12% of workplaces use 'machines or systems that determine the content and pace of work', 8% use 'machines or systems that monitor worker performance', and 5% use 'wearable devices'. These digital technologies enable AIWM as they potentially integrate some degree of AI and are potentially used to manage workers in some aspect. In addition, according to reports by McKinsey (2020) and Oracle (2019), over 50% of workplaces that they surveyed use some sort of AI in at least one area of their company, including worker management. However, in practice, many managers and employers are often unable to differentiate between AI and simpler data-driven approaches, which skews the data and implies that the results from McKinsey and Oracle are not completely reliable.

AIWM systems might bring value to organisations, such as helping to improve productivity and efficiency and to identify OSH risks in the workplace. However, they can also lead to a large array of ethical and privacy issues, as well as to OSH risks. For example, **fully automating the decision-making process through AI-based systems may result in unsafe, unfair and discriminatory decisions as well as in workers not being able to contest the decision, which leads to a loss of autonomy and job control**. This, in turn, might lead to the dehumanisation of workers where they are treated not as humans but as collections of data points that need to be 'fixed' to ensure productivity and efficiency. This might be further exacerbated by **intrusive worker monitoring systems**. For example, tools that can infer an individual's mood from their facial expressions, body language and speech patterns can make workers feel eerie and uncomfortable, forcing them to behave unnaturally and overenthusiastically. AIWM systems might also **exacerbate some discriminatory biases in organisations**. For example, if an AIWM system for worker recruitment is based on recruitment patterns that favour a particular race, gender or age, such a system might continue this pattern. In addition, granting autonomy to AIWM systems to make decisions might lead to **issues with accountability** as it is unclear who is to blame if such a system makes a mistake that leads to a negative OSH consequence.

Hence, due to the potential transformative effect of AI on work, the workplace and the workforce, it is crucial to have a strong regulatory base than can mitigate its possible negative consequences. **At the EU level, some regulations already exist that contribute towards addressing the possible negative effects of AIWM**, including: (i) the EU OSH acquis that include provisions, albeit generic, that are applicable to AIWM; (ii) the GDPR that covers personal data that might be used in AIWM; and (iii) the EU anti-discrimination law. In addition, in April 2021 the European Commission drafted a Proposal for a Regulation on a European Approach for AI that, if accepted, would be the first EU-wide regulation specifically targeting AI, which also covers certain AIWM applications and risks. However, according to the academic literature, interviews and discussions with experts, some gaps remain at the EU level. These include, but are not limited to, many regulations lacking the 'voice of workers', a weak enforcement of these laws and lack of provisions attributing accountability for the mistakes of AI systems.

Similarly, **at the Member State level, some AI-related provisions exist, but they are, in many cases, broad in scope and do not focus specifically on AIWM and its effect on OSH**. For example, at least 20 out of 27 EU Member States, as well as Norway and Switzerland, have adopted AI strategies, but the majority of them are rather general and rarely include provisions explicitly related to AI systems that interact with, or might directly affect, workers, but some exceptions exist. For example, **Czech, German and French national AI strategies** explicitly address the use of AI in the workplace. In France, there is also the **El Khomri Law** that is relevant to worker monitoring and management as it grants a worker the 'right to disconnect' from work completely after working hours (for example, employers cannot monitor workers after work hours). In some Member States there are also several codes of practice on the use of AI that also is related to AIWM systems. These include, but are not limited to, a **concept paper on how to deploy and use AI in business in Germany**, **operational indications on the installation and use of support tools, including AI-based ones, in call centres in Italy**, and **guidelines on worker monitoring in Cyprus**.

However, gaps still exist, and, hence, based on the findings of the research presented in the previous sections, **a number of recommendations that can be used to mitigate risks to workers' safety, health and wellbeing that are associated with the design and use of AIWM systems were formulated**:

Recommendation 1:
Making the design, development and use of AIWM systems human-centred, so that they are used **to support** workers and leave **humans in control**. This would also guarantee that the compassion, empathy and care for workers brought by humans is not replaced by computer decision-making that solely tries to increase profits for a business.

Recommendation 2:
Ensuring workers' participation, consultation and social dialogue. Workers should be included in the design, development and testing phases, and ex ante and ex post assessments, as well as usage of AI-based systems. The inclusion of workers at all stages of AI development and usage will contribute to making such systems trustworthy, human-centred and remaining under human control. This can also be achieved by enforcing the co-governance of AIWM systems, **giving a say to workers on how AIWM is developed, acquired, introduced and used**. This is key to preventing the possible risks of AIWM to OSH.

Recommendation 3:
Fostering a holistic approach in evaluating AIWM systems encompasses including different stakeholders in the evaluation process, as well as ensuring that such systems are not evaluated in a vacuum; it also covers the effects AIWM might have on workers and society as a whole. The **evaluation process should also be a dynamic process rather than a one-off exercise** as AI-based systems are able to evolve through self-learning, which might lead to some systems that were safe in the past becoming dangerous for workers.

Recommendation 4:
Improving the design, development and use of AI-based systems by making the functioning and purpose of AIWM transparent, explainable and understandable. This might be ensured by introducing more binding requirements for AIWM providers and developers to ensure that **workers' health, safety and wellbeing are already considered from the design stage**. This should also go hand-in-hand with a strong enforcement policy ensuring that organisations comply with regulations.

Recommendation 5:
Establishing a clear line of responsibility indicating who is responsible for ensuring that an AIWM system does not cause harm to workers, break the law or malfunction. This includes establishing oversight mechanisms, remedies on how the negative effect of AIWM can be mitigated, and a course of action on what to do if managers fail to govern the AIWM system. Ensuring the line of

responsibility could also go beyond simply stating that an employer in general is responsible for AIWM systems by instead requiring organisations to specifically name responsible managers.

Recommendation 6:
Improving workers' privacy and data protection by increasing transparency about data collection and usage and introducing better reporting mechanisms on misuses of AIWM tools. More specifically, workers should have the right to edit or block algorithmic inferences, and to contest automated decisions, and they should also be ensured full freedom to refuse to give consent to collect their data by additional provisions prohibiting lay-offs or any other negative actions against workers in these cases. This can be expanded upon by **ensuring workers the right to an explanation** for decisions made by algorithms. This includes what private data the algorithm used, how these data were collected and how it made its decision.

Recommendation 7:
Ensuring the right to disconnect for workers. In addition to its primary goal of guaranteeing workers the right to disconnect from work during non-working hours, it could also serve as a means to ensure workers' privacy and personal data protection, in particular when it relates to a disproportionate amount of monitoring and surveillance not strictly necessary for a legitimate purpose.

Recommendation 8:
There is a need for knowledge exchange, dissemination and awareness building on AIWM and how it might affect OSH. This might include creating a dialogue involving relevant stakeholders, such as representatives of workers, employers, OSH authorities, experts and AIWM tool developers. The dialogue should be open, allow all sides to express their opinions, and focus not only on what should be controlled, banned and mitigated, but also on how to ethically use AI-based tools.

Recommendation 9:
Worker privacy and data protection can also be improved by **enhancing labour inspectorates' capacities and cooperation with national data protection authorities**. This includes improving their knowledge about AIWM and how it might affect OSH, as well as providing tools to labour inspectors for closer cooperation with data protection officers on questions relating to how AIWM and similar AI-based systems affect OSH.

Recommendation 10:
More education efforts that enhance workers' and employers' AI literacy by promoting qualification and skills development for AIWM applications. This would empower them to better understand AIWM systems and thereby be able to exert their right of consultation and participation in the design and implementation of such systems. Education and awareness-raising efforts should focus on ensuring that current and future AIWM systems put humans and their health, safety and wellbeing at the centre.

Recommendation 11:
Ensuring transparency between developers of AIWM systems and deploying organisations. This includes, but is not limited to, sharing with organisations how such a tool operates, how it makes decisions, what kind of risks and negative effects it can create, its benefits and drawbacks, and so on. However, if full transparency is not possible, any agreement should include the caveat that if a system causes harm and the deploying company has no right to demand that the system be changed, the system would be shut down at once by such system developers.

6 References

Access Now (2018). *Human rights in the age of artificial intelligence*. Access Now. https://www.accessnow.org/cms/assets/uploads/2018/11/AI-and-Human-Rights.pdf

Abd-Alrazaq, A. A., Rababeh, A., Alajlani, M., Bewick, B. M., & Househ, M. (2020). Effectiveness and safety of using chatbots to improve mental health: Systematic review and meta-analysis. *Journal of Medical Internet Research, 22*(7), Article e16021. https://doi.org/10.2196/16021

Adadi, A., & Berrada, M. (2018). Peeking inside the black-box: A survey on explainable artificial intelligence (XAI). *IEEE Access, 6*, 52138-52160. https://doi.org.10.1109/ACCESS.2018.2870052

Adrill, L. (2021). *Workplace surveillance: Savy solution or a step too far?* Siliconrepublic. https://www.siliconrepublic.com/careers/workplace-surveillance-facial-recognition-tech

Afshar, V. (2021). *AI-powered virtual assistants and the future of work.* Zdnet. https://www.zdnet.com/article/ai-powered-virtual-assistants-and-future-of-work/

Ajana, B. (2020). Personal metrics: Users' experiences and perceptions of self-tracking practices and data. *Social Science Information, 59*(4), 654-678. https://doi.org/10.1177/0539018420959522

Ajunwa, I., Crawford, K., & Schultz, J. (2017). Limitless worker surveillance. *California Law Review, 105*(3), 735-776. https://www.californialawreview.org/print/3-limitless-worker-surveillance/

Albrecht, S. L., Green, C. R., & Marty, A. (2021). Meaningful work, job resources, and employee engagement. *Sustainability, 13*(7), 40-45. https://doi.org/10.3390/su13074045

AlgorithmWatch (2019). *Atlas of automation. Automated decision-making and participation in Germany*. AlgorithmWatch. https://atlas.algorithmwatch.org/wp-content/uploads/2019/04/Atlas_of_Automation_by_AlgorithmWatch.pdf

Aloisi, A. and 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.

Amoore, L., & Piotukh, V. (2015). *Algorithmic life: Calculative devices in the age of big data*. Taylor and Francis.

Aranguiz, A. (2021, September 2). *Platforms put a spoke in the wheels of Spain's 'riders' law'*. Social Europe. https://socialeurope.eu/platforms-put-a-spoke-in-the-wheels-of-spains-riders-law

Awan, S. H., Habib, N., Shoaib Akhtar, C., & Naveed, S. (2020). Effectiveness of performance management system for employee performance through engagement. *SAGE Open, 10*(4). https://doi.org/10.1177/2158244020969383

Badri, A., Boudreau-Trudel, B., & Souissi, A. S. (2018). Occupational health and safety in the industry 4.0 era: A cause for major concern? *Safety Science, 109*, 403-411. https://doi.org/10.1016/j.ssci.2018.06.012

Ball, K. (2010). Workplace surveillance: an overview. *Labor History, 51*(1), 87-106. https://doi.org/10.1080/00236561003654776

Ball, K. (2021). *Electronic monitoring and surveillance in the workplace: Literature review and policy recommendations*. European Commission. https://publications.jrc.ec.europa.eu/repository/handle/JRC125716

Bassi, L. (2011). Raging debates in HR analytics. *People and Strategy, 34*(2), 14-19. https://mcbassi.com/wp/wp-content/uploads/2018/06/RagingDebatesInHRAnalytics.pdf

BellHawk. (2016). *Real-time artificial intelligence for scheduling and planning make-to-order manufacturing*. BellHawk Systems Corporation. https://industrytoday.com/wp-content/uploads/2016/11/real-time-ai-make-to-order-whitepaper.pdf

Belton, P. (2019, April 12). *How does it feel to be watched at work all the time?* BBC News. https://www.bbc.com/news/business-47879798

Benjamin, R. (2020). *Race after technology abolitionist tools for the new Jim code*. Polity.

Bérastégui, P. (2021). *Exposure to psychosocial risk factors in the gig economy: A systematic review*. European Trade Union Institute. https://www.etui.org/sites/default/files/2021-02/Exposure%20to%20psychosocial%20risk%20factors%20in%20the%20gig%20economy-a%20systematic%20review-2021.pdf

Black, J., & Schaefer, D. (2021, April 28). *Deutsche Bank sees remote work for up to three days a week*. Bloomberg. https://www.bloomberg.com/news/articles/2021-04-28/deutsche-bank-sees-flexible-working-for-up-to-three-days-a-week

Boiral, O., Brotherton, M. C., Rivaud, L., & Guillaumie, L. (2021). Organizations' management of the COVID-19 pandemic: A Scoping Review of Business Articles. *Sustainability, 13*(7), Article 3993. https://doi.org/10.3390/su13073993

Borgesius, F. J. Z. (2020). Strengthening legal protection against discrimination by algorithms and artificial intelligence. *The International Journal of Human Rights, 24*(10), 1572-1593. https://doi.org/10.1080/13642987.2020.1743976

Bradley, A. J. (2020, August 10). *Brace yourself for an explosion of virtual assistants.* Gartner. https://blogs.gartner.com/anthony_bradley/2020/08/10/brace-yourself-for-an-explosion-of-virtual-assistants/

Brady, T. M. (2016). Wrist band haptic feedback system. https://patents.google.com/patent/US9881277B2/

Bråten, M. (2017). Bruk av digitale kontrollteknologier og ivaretakelse av personvern i arbeidsforhold. *Magma, 6*, 54-62.

Brin, D. (2019, May 20). *France and Spain: Right to disconnect spreads.* SHRM. https://www.shrm.org/resourcesandtools/legal-and-compliance/employment-law/pages/global-france-spain-right-to-disconnect.aspx

Brione, P. (2020). *My boss the algorithm: An ethical look at algorithms in the workplace.* Advisory, Conciliation and Arbitration Service. https://www.acas.org.uk/my-boss-the-algorithm-an-ethical-look-at-algorithms-in-the-workplace

Brower, H. H., Lester, S. W., Korsgaard, M. A., & Dineen, B. R. (2009). A closer look at trust between managers and subordinates: Understanding the effects of both trusting and being trusted on subordinate outcomes. *Journal of Management, 35*(2), 327-347. https://doi.org/10.1177%2F0149206307312511

Browne, S. (2017). *HR on purpose: Developing deliberate people passion*. Society For Human Resource Management.

Bruce, K., & Nyland, C. (2011). Elton Mayo and the deification of human relations. *Organization Studies, 32*(3), 383-405. https://doi.org/10.1177%2F0170840610397478

Cabrelli, D., & Graveling, R./European Parliament. (2019). *Briefing on health and safety in the workplace of the future.* https://www.europarl.europa.eu/meetdocs/2014_2019/plmrep/COMMITTEES/EMPL/DV/2019/09-24/EMPL20190924_HealthandSafety_briefing.EN.pdf

Calvo, R. A., Milne, D. N., Hussain, M. S., & Christensen, H. (2017). Natural language processing in mental health applications using non-clinical texts. *Natural Language Engineering, 23*(5), 649-685. https://psycnet.apa.org/doi/10.1017/S1351324916000383

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 L. Hall, T. Flint, S. O'Hara, & P. Turner (Eds), *Proceedings of the 31st International BCS Human Computer Interaction Conference (HCI 2017)* (pp. 1-7). BCS Learning and Development Ltd. http://dx.doi.org/10.14236/ewic/HCI2017.24

Cascio, W. F., & Montealegre, R. (2016). How technology is changing work and organizations. *Annual Review of Organizational Psychology and Organizational Behavior, 3*, 349-375. https://doi.org/10.1146/annurev-orgpsych-041015-062352

Cater, L., & Heikkilä, M. (2021, May 27). *Your boss is watching: How AI-powered surveillance rules the workplace.* Politico. https://www.politico.eu/article/ai-workplace-surveillance-facial-recognition-software-gdpr-privacy/

Cedefop, & Eurofound. (2019a). *European Company Survey 2019: Online questionnaire for Management respondents.* https://www.eurofound.europa.eu/surveys/2019/european-company-survey-2019

Cedefop & Eurofound. (2019b). *European Company Survey 2019: Sampling and weighting report.* https://www.eurofound.europa.eu/surveys/2019/european-company-survey-2019/methodology/sampling-weighting

Council of Europe. (2019). *Unboxing artificial intelligence: 10 steps to protect human rights.* https://rm.coe.int/unboxing-artificial-intelligence-10-steps-to-protect-human-rights-reco/1680946e64

Chamorro-Premuzic, T. (2020). Can surveillance AI make the workplace safe? *MIT Sloan Management Review, 62*(1), 13-15. https://sloanreview.mit.edu/article/can-surveillance-ai-make-the-workplace-safe/

Circolare (N. 4/2017). *INL CIRCOLARI REGISTRAZIONE N. 4 DEL 26/07/2017.* https://www.ispettorato.gov.it/it-it/orientamentiispettivi/Documents/Circolari/INL-circolare-4-2017-call-center-e-videosorveglianza.pdf

COE (Council of Europe) (2018). *Modernised Convention for the Protection of Individuals with Regard to the Processing of Personal Data.* https://search.coe.int/cm/Pages/result_details.aspx?ObjectId=09000016807c65bf

Colclough, C. (2020, September 3). *Workers' rights: Negotiating and co-governing digital systems at work.* Social Europe. https://www.socialeurope.eu/workers-rights-negotiating-and-co-governing-digital-systems-at-work

Collins, L., Fineman, D. R., & Tshuchica, A. (2017, February 28). *People analytics: Recalculating the route.* Deloitte Insights. https://www2.deloitte.com/us/en/insights/focus/human-capital-trends/2017/people-analytics-in-hr.html

Comeau, M. (2021). *Intelligence artificielle en santé et SST.* Institut de recherche Robert-Sauvé en santé et en sécurité du travail. https://www.irsst.qc.ca/publications-et-outils/publication/i/101104/n/intelligence-artificielle

Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2009). *Introduction to algorithms.* MIT Press.

Dasgupta, A., & Wendler, S. (2019). *AI adoption strategies.* Centre for Technology & Global Affairs: https://www.ctga.ox.ac.uk/article/ai-adoption-strategies

Dastin, J. (2018, October 11). *Amazon scraps secret AI recruiting tool that showed bias against women.* Reuters. https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G

David, L. S., Goldstein, J. C., Hessami, G. A., Shaw, P., Watson, E., & Weger, G. (2020). *IEEE use case— Criteria for addressing ethical challenges in transparency, accountability, and privacy of contact tracing—Draft.* Call For Global Consultation. https://engagestandards.ieee.org/rs/211-FYL-955/images/ECPAIS_USECASE_10132020_DRAFT.pdf

De Mauro, A., Greco, M., & Grimaldi, M. (2015). What is big data? A consensual definition and a review of key research topics. *AIP Conference Proceedings, 1644*(1), 97-104. https://doi.org/10.1063/1.4907823

De Stefano, V. (2018). *"Negotiating the algorithm": Automation, artificial intelligence and labor protection*. ILO Employment Policy Department Working Paper No. 246, International Labour Office. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_policy/documents/publication/wcms_634157.pdf

De Stefano, V. (2020). Algorithmic bosses and what to do about them: Automation, artificial intelligence and labour protection. In D. Marino & M. Monaca (Eds), *Economic and policy implications of artificial intelligence. Studies in systems, decision and control (Vol. 288)* (pp. 65-86). Springer.

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/

De Stefano V., Durri, I., Stylogiannis, C., & Wouters, M. (2020). "*System needs update": Upgrading protection against cyberbullying and ICT-enabled violence and harassment in the world of work*. ILO Working Paper 1, International Labour Office. https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---travail/documents/publication/wcms_736235.pdf

De Stefano, V., & Aloisi, A. (2021). *Artificial intelligence and workers' rights*. Social Europe. https://socialeurope.eu/artificial-intelligence-and-workers-rights

Deadrick, D. L., & Stone, D. L. (2014). Human resource management: Past, present, and future. *Human Resource Management Review, 3*(24), 193-195. https://doi.org/10.1016/j.hrmr.2014.03.002

Deobald, U. L., Busch, T., Schank, C., Weibel, A., Schafheitle, S., Wildhaber, I., & Kasper, G. (2019). The challenges of algorithm-based HR decision-making for personal integrity. *Journal of Business Ethics, 160*(2), 377-392. https://doi.org/10.1007/s10551-019-04204-w

DGB (German Trade Union Confederation) (2020). *Artificial intelligence (AI) for good work.* International Telecommunication Union (ITU). https://www.dgb.de/downloadcenter/++co++b794879a-9f2e-11ea-a8e8-52540088cada

Dilmegani, C. (2021). *Future of AI according to top AI experts of 2021: In-depth Guide*. https://research.aimultiple.com/future-of-ai/

Dourish, P. (2016). Algorithms and their others: Algorithmic culture in context. *Big Data & Society, 3*(2). https://doi.org/10.1177%2F2053951716665128

Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over machine - The power of human intuition and expertise in the era of the computer.* Basil Blackwell.

Duffy, K. (2021, April 19). *Facebook says its staff can continue working from home after the pandemic.* Business Insider. https://www.businessinsider.com/facebook-staff-work-from-home-after-coronavirus-pandemic-twitter-2021-4

Dzieza, J. (2020, February 27). *How hard will the robots make us work?* The Verge. https://www.theverge.com/2020/2/27/21155254/automation-robots-unemployment-jobs-vs-human-google-amazon

Eager J., Whittle, M., Smit, J., Cacciaguerra, G., & Lale-Demoz E. (2020). *Opportunities of artificial intelligence.* Study report, European Parliament. https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652713/IPOL_STU(2020)652713_EN.pdf

ECHR (European Court of Human Rights) (2007). *Judgment in the Case of DH and Others v. The Czech Republic, No. 57325/00no. 13 November 2007,* Strasbourg. https://hudoc.echr.coe.int/fre#{%22itemid%22:[%22001-83256%22]}

ECHR (European Court of Human Rights) (2016). *Judgement on the Case of Biao v. Denmark, no. 38590/10.* Strasbourg. https://hudoc.echr.coe.int/fre#{%22itemid%22:[%22001-163115%22]}

Edwards, L., Martin, L., & Henderson, T. (2018). Employee surveillance: The road to surveillance is paved with good intentions. *SSRN Electronic Journal*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3234382

Estévez-Mujica, C. P., & Quintane, E. (2018). E-mail communication patterns and job burnout. *PloS One, 13*(3), Article e0193966. https://doi.org/10.1371/journal.pone.0193966

ETUI (European Trade Union Institute) (2020). *Labour in the age of AI: Why regulation is needed to protect workers.* Foresight Brief. https://www.etui.org/sites/default/files/ForesightBriefs2020.pdf

European Agency for Safety and Health at Work (EU-OSHA) (2017). *Monitoring technology: The 21st century's pursuit of wellbeing*. https://oshwiki.eu/wiki/Monitoring_technology:_the_21st_Century%27s_pursuit_of_wellbeing%3F

European Agency for Safety and Health at Work (EU-OSHA) (2019). *OSH and the future of work: Benefits and risks of artificial intelligence tools in workplaces.* Discussion paper. https://osha.europa.eu/sites/default/files/publications/documents/OSH_future_of_work_artificial_intelligence_0.pdf

European Agency for Safety and Health at Work (EU-OSHA) (2020a). *ESENER 2019: What does it tell us about safety and health in Europe's workplaces?* Policy brief. file:///D:/Chrome%20Downloads/ESENER_2019_Policy_brief_EN%20(3).pdf

European Agency for Safety and Health at Work (EU-OSHA) (2020b). *ESENER 3: Technical Report: Final version (14.01.2020).* https://oshwiki.eu/images/a/aa/Technical_Report_ESENER3_Final.pdf

European Agency for Safety and Health at Work (EU-OSHA) (2021a). *Digital platform work and occupational safety and health: A review*. https://osha.europa.eu/en/publications/le-travail-sur-plateformes-numeriques-et-la-sante-et-la-securite-au-travail-analyse

European Agency for Safety and Health at Work (EU-OSHA) (2021b). *Teleworking during the COVID-19 pandemic: risks and prevention strategies*. https://osha.europa.eu/en/publications/teleworking-during-covid-19-pandemic-risks-and-prevention-strategies/view

European Agency for Safety and Health at Work (EU-OSHA). (2022a). *Artificial intelligence for worker management: implications for Occupational Safety and Health.*

European Agency for Safety and Health at Work (EU-OSHA). (2022b). *Advanced robotics, artificial intelligence and the automation of tasks: definitions, uses, policies and strategies and Occupational Safety and Health*. https://osha.europa.eu/en/publications/advanced-robotics-artificial-intelligence-and-automation-tasks-definitions-uses-policies-and-strategies-and-occupational-safety-and-health

European Agency for Safety and Health at Work (EU-OSHA) (2022c). *Spain: The 'Riders' Law', new regulation on digital platform work*. https://osha.europa.eu/en/publications/spain-riders-law-new-regulation-digital-platform-work

Eurofound (2020a). *Telework and ICT-based mobile work: Flexible working in the digital age*. New forms of employment series, Publications Office of the European Union. https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef19032en.pdf

Eurofound (2020b). *Working conditions. Employee monitoring and surveillance: The challenges of digitalisation.* Publications Office of the European Union. https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef20008en.pdfEurofound (2020c). *COVID-19. Living, working and COVID-19*. Publications Office of the European Union. https://www.eurofound.europa.eu/publications/report/2020/living-working-and-covid-19

European Commission (2018a). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions.* Artificial Intelligence for Europe. COM(2018) 237 final. https://ec.europa.eu/transparency/documents-register/detail?ref=COM(2018)237&lang=en

European Commission (2018b). *Evaluation of the Machinery Directive.* https://ec.europa.eu/docsroom/documents/29232

European Commission (2020). *Communication from The Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Fostering a European approach to Artificial Intelligence COM/2021/205 final.* https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2021:205:FIN

European Commission (2021, April 21). *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*. European Commission, COM(2021) 206 final. https://eur-lex.europa.eu/resource.html?uri=cellar:e0649735-a372-11eb-9585-01aa75ed71a1.0001.02/DOC_1&format=PDF

European Parliament (2019). *Understanding algorithmic decision-making: Opportunities and challenges.* European Parliamentary Research Service. https://www.europarl.europa.eu/RegData/etudes/STUD/2019/624261/EPRS_STU(2019)624261_EN.pdf

European Parliament (2020). *Report with recommendations to the Commission on a framework of ethical aspects of artificial intelligence, robotics and related technologies.* https://www.europarl.europa.eu/doceo/document/A-9-2020-0186_EN.html

European Parliamentary Research Services (2020a). *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

European Parliamentary Research Services (2020b). *The impact of the General Data Protection Regulation (GDPR) on artificial intelligence.* https://www.europarl.europa.eu/RegData/etudes/STUD/2020/641530/EPRS_STU(2020)641530_EN.pdf

ETUC (2021) *Position on the right to disconnect*. European Trade Union Confederation (ETUC). https://www.etuc.org/en/document/etuc-position-right-disconnect#_ftn11

Feloni, R. (2017, August 23). *I tried the software that uses AI to scan job applicants for companies like Goldman Sachs and Unilever before meeting them — And it's not as creepy as it sounds.* Business Insider. https://www.businessinsider.com/hirevue-ai-powered-job-interview-platform-2017-8

Felstead, A., Gallie, D., Green, F., & Henseke, G. (2019). The determinants of skills use and work pressure: A longitudinal analysis. *Economic and Industrial Democracy, 40*(3), 730-754. https://doi.org/10.1177/0143831X16656412

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

Fernandez, V., & Gallardo-Gallardo, E., (2020). Tackling the HR digitalization challenge: Key factors and barriers to HR analytics adoption. *Competitiveness Review: An International Business Journal, 31*(1), 162-187. https://doi.org/10.1108/CR-12-2019-0163

Fisher, A. (2019, August 1). *HR managers, with a little help from AI, can decide your next pay hike.* The Print. https://theprint.in/features/hr-managers-with-a-little-help-from-ai-can-decide-your-next-pay-hike/270927/

Fjelland, R. (2020). Why general artificial intelligence will not be realized. *Humanities and Social Sciences Communications, 7*, Article 10. https://doi.org/10.1057/s41599-020-0494-4

Financial Management (2020, February 1). *Data privacy risks to consider when using AI.* https://www.fm-magazine.com/issues/2020/feb/data-privacy-risks-when-using-artificial-intelligence.html

Gal, U., Jensen, T. B., & 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

Gandomi, A., & Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics. *International Journal of Information Management, 35*(2), 137-144. https://doi.org/10.1016/j.ijinfomgt.2014.10.007

Garcez, A., & Lamb, L. (2020). Neurosymbolic AI: The 3rd wave. *ArXiv, abs/2012.05876. https://arxiv.org/abs/2012.05876*

Garzia, C. (2013). *Workplace surveillance: Good watchdog or cynical control*? Unpublished master's thesis, University of London.

George, C. (1968). *The history of management thought*. Prentice Hall.

Gianatti, T.-L. (2020, May 14). *How AI-driven algorithms improve an individual's ergonomic safety.* OH&S. https://ohsonline.com/Articles/2020/05/14/How-AIDriven-Algorithms-Improve-an-Individuals-Ergonomic-Safety.aspx?Page=1

Gigauri, I. (2020). Implications of COVID-19 for human resource management. *SSRG International Journal of Economics and Management Studies, 7*(11), 25-33. https://doi.org/10.14445/23939125/IJEMS-V7I11P104

Główny Urząd Statystyczny (Statistics Poland). (2020). *Development of methodology and survey of the degree of adjustment of selected enterprises to the economic requirements of the fourth wave of the industrial revolution (Industry 4.0).* https://stat.gov.pl/statystyki-eksperymentalne/badania-i-rozwoj-innowacyjnosc-spoleczenstwo-informacyjne/wypracowanie-metodologii-oraz-badanie-stopnia-dostosowania-wybranych-przedsiebiorstw-do-wymogow-gospodarczych-jakie-stawia-czwarta-fala-rewolucji-przemyslowej-przemysl-4-0,13,1.html

Gluyas, L., & Day, S. (2018). Artificial intelligence – Who is liable when AI fails to perform? CMS. https://cms.law/en/gbr/publication/artificial-intelligence-who-is-liable-when-ai-fails-to-perform

Goodfellow, I., Bengio, Y., & Courville, A. (2017). *Deep learning*, *1*. The MIT Press.

Govaert, M., van Beers, A., & Daniels, C. (2021, March 25). *The right to disconnect.* Global Workplace Insider. https://www.globalworkplaceinsider.com/2021/03/the-right-to-disconnect/

Grządzielewska, M. (2021). Using machine learning in burnout prediction: A survey. *Child and Adolescent Social Work Journal, 38*(2), 175-180. https://doi.org/10.1007/s10560-020-00733-w

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/

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

Holland, P. J., Cooper, B., & Hecker, R. (2015). Electronic monitoring and surveillance in the workplace. *Personnel Review, 44*, 161-175. https://doi.org/10.1108/PR-11-2013-0211

Huang, K., Hallinan, K. P., Lou, R., Alanezi, A., Alshatshati, S., & Sun, Q. (2020). Self-learning algorithm to predict indoor temperature and cooling demand from smart WiFi thermostat in a residential building. *Sustainability, 12*(17), Article 7110. https://doi.org/10.3390/su12177110

Hughes, C., Robert, L., Frady, K., & Arroyos, A. (2019). Artificial intelligence, employee engagement, fairness, and job outcomes. In *Managing technology and middle- and low-skilled employees (The changing context of managing people* (pp. 61-68). Emerald Publishing Limited. https://doi.org/10.1108/978-1-78973- 077-720191005

Ilkou, E., & Koutraki, M. (2020). Symbolic vs sub-symbolic AI methods: Friends or enemies? In *Proceedings of the CIKM 2020 Workshops*. CEUR Workshop Proceedings. https://doi.org/10.1145/3340531.3414072

Imre-Millei, B. (2021, March 20). *No lies: The problem with biometric emotion detection.* The Observer. https://theobserver-qiaa.org/no-lies-the-problem-with-biometric-emotion-detection

Incheon National University (2021, February 11). *Artificial emotional intelligence: A safer, smarter future with 5G and emotion recognition.* Science Daily. https://www.sciencedaily.com/releases/2021/02/210211113917.htm

ITU (2018). Assessing the economic impact of artificial intelligence*. Issue Paper No. 1.* International Telecommunication Union (ITU). https://www.itu.int/dms_pub/itu-s/opb/gen/S-GEN-ISSUEPAPER-2018-1-PDF-E.pdf

Jarrahi, M. H. (2018). Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. *Business Horizons, 61*(4), 577-586. https://doi.org/10.1016/j.bushor.2018.03.007

Joint Research Centre (JRC) (2020). *Telework in the EU before and after the COVID-19: Where we were, where we head to*. European Commission. https://ec.europa.eu/jrc/sites/jrcsh/files/jrc120945_policy_brief_-_covid_and_telework_final.pdf

Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. *Science, 349*(6245), 255-260. https://doi.org/10.1126/science.aaa8415

JRC-OECD (2021). *National strategies on artificial intelligence: A European perspective.* Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC122684

Juniper Networks (2021). *AI is set to accelerate... Is your organization ready?* https://www.juniper.net/content/dam/www/assets/additional-resources/us/en/juniper-ai-research-paper.pdf

Kelion, L. (2019, December 12). *Emotion-detecting tech should be restricted by law - AI now*. BBC News*.* https://www.bbc.com/news/technology-50761116

Kelly, J. (2021, September 26). *The future of hybrid and remote work will increase. Orwellian big-brother 'tattleware' spyware for surveilling workers.* Forbes. https://www.forbes.com/sites/jackkelly/2021/09/26/the-future-of-hybrid-and-remote-work-will-increase-orwellian-big-brother-tattleware-spyware-for-surveilling-workers/

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

Kessler, F. (2016). *Labor Reforms 2015-2016 In France: "Macron" And "Rebsamen" Laws, The "El Khomri" Draft Legislation.* https://www.raco.cat/index.php/IUSLabor/article/download/318006/408057/

Köchling, A., & Wehner, M. C. (2020). Discriminated by an algorithm: A systematic review of discrimination and fairness by algorithmic decision-making in the context of HR recruitment and HR development. *Business Research, 13*, 795-848. https://doi.org/10.1007/s40685-020-00134-w

Koontz, H., & O'Donnell, C. (1955). *Principles of management: An analysis of managerial functions*. McGraw-Hill.

Kronos (2018). *Employee scheduling.* https://www.kronos.com/2018/products/employee-scheduling

Lane, M., & Saint-Martin, A. (2021). *The impact of artificial intelligence on the labour market: What do we know so far?* OECD Social, Employment and Migration Working Papers, No. 256. OECD Publishing. https://doi.org/10.1787/7c895724-en

Lau, J., Zimmerman, B., & Schaub, F. (2018). Alexa, are you listening? Privacy perceptions, concerns and privacy-seeking behaviors with smart speakers.*Proceedings of the ACM on Human-Computer Interaction, 2*(CSCW), 1-31. https://doi.org/10.1145/3274371

Lima, G., Costa, R., & Moreno, M. (2019). October. Semantics and multimedia: An introduction to symbolic artificial intelligence applied to multimedia. In *Proceedings of the 25th Brazillian Symposium on Multimedia and the Web*, 7-9. https://doi.org/10.1145/3323503.3345031

Loveys, K., Fricchione, G., Kolappa, K., Sagar, M., & Broadbent, E. (2019). Reducing patient loneliness with artificial agents: Design insights from evolutionary neuropsychiatry. *Journal of Medical Internet Research, 21*(7), Article e13664. https://doi.org/10.2196/13664

Mahidhar, V., & Davenport, T. H. (2018, May 10). What's your cognitive strategy. *MIT Sloan Management Review, 59*(4), 19-23. https://sloanreview.mit.edu/article/whats-your-cognitive-strategy/

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

Maity, S. (2019). Identifying opportunities for artificial intelligence in the evolution of training and development practices. *Journal of Management Development, 38*(8), 651-663. https://doi.org/10.1108/JMD-03-2019-0069

Makanawala, P., Godara J., Goldwasser E., & Le, H. (2013). Applying gamification in customer service application to improve agents' efficiency and satisfaction. In A. Marcus (Ed.), *Design, user experience, and usability. Health, learning, playing, cultural, and cross-cultural user experience*. Lecture Notes in Computer Science (8013). Springer.

Malgieri, G., & Comandé, G. (2017). Why a right to legibility of automated decision-making exists in the General Data Protection Regulation. *International Data Privacy Law, 7*(4), 243-265. https://doi.org/10.1093/idpl/ipx019

Malgieri, G., & Ienca, M. (2021). *The EU regulates AI but forgets to protect our mind* [European Law Blog]. https://europeanlawblog.eu/2021/07/07/the-eu-regulates-ai-but-forgets-to-protect-our-mind/

Manokha, I. (2017, January 3). *Why the rise of wearable tech to monitor employees is worrying.* The Conversation. https://theconversation.com/why-the-rise-of-wearable-tech-to-monitor-employees-is-worrying-70719

Marcus, G. (2019, August 14). *DeepMind's losses and the future of artificial intelligence.* Wired. https://www.wired.com/story/deepminds-losses-future-artificial-intelligence/

Marler, J. H., & Boudreau, J. W. (2017). An evidence-based review of HR Analytics. *The International Journal of Human Resource Management, 28*(1), 3-26. https://doi.org/10.1080/09585192.2016.1244699

Martin, K. (2018). Ethical implications and accountability of algorithms. *Journal of Business Ethics, 160*(4), 835-850. https://doi.org/10.1007/s10551-018-3921-3

Martín-Martín, A., Thelwall, M., Orduna-Malea, E., & Delgado López-Cózar, E. (2020). Google scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations' COCI: A multidisciplinary comparison of coverage via citations. *Scientometrics, 126*(1), 871-906. https://doi.org/10.1007/s11192-020-03690-4

Mason, S. (2018, November 20). High score, low pay: Why the gig economy loves gamification. *The Guardian*. https://www.theguardian.com/business/2018/nov/20/high-score-low-pay-gamification-lyft-uber-drivers-ride-hailing-gig-economy

Mateescu, A., & Nguyen, A. (2019, February 6). *Explainer: Algorithmic management in the workplace.* Data & Society. https://datasociety.net/library/explainer-algorithmic-management-in-the-workplace/

McCann FitzGerald. (2021). *General Data Protection Regulation: A survey of the impact of GDPR and its effect on organisations in Ireland.* https://www.mccannfitzgerald.com/uploads/GDPR_Report_2021_January.pdf

McIntosh, S. (2018). *A guide to remote working and virtual teams.* Sage Advice. https://www.sage.com/en-gb/blog/remote-working-virtual-teams/

McIver, D., Lengnick-Hall, M. L., & Lengnick-Hall, C. A. (2018). A strategic approach to workforce analytics: Integrating science and agility. *Business Horizons, 61*(3), 397-407. https://doi.org/10.1016/j.bushor.2018.01.005

McKinsey. (2020). *Global survey: The state of AI in 2020.* McKinsey Global Publishing. https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/global-survey-the-state-of-ai-in-2020

McNall, L. A., & Stanton, J. M. (2011). Private eyes are watching you: Reactions to location sensing technologies. *Journal of Business and Psychology, 26*(3), 299-309. https://doi.org/10.1007/s10869-010-9189-y

Ministry of Industry and Trade of Czech Republic (2019). *The National Artificial Intelligence Strategy of the Czech Republic*. https://www.mpo.cz/assets/en/guidepost/for-the-media/press-releases/2019/5/NAIS_eng_web.pdf

Mishra, S. N., Lama, D. R., & Pal, Y. (2016). Human Resource Predictive Analytics (HRPA) for HR management in organizations. *International Journal of Scientific & Technology Research, 5*(5), 33-35. https://www.ijstr.org/final-print/may2016/Human-Resource-Predictive-Analytics-hrpa-For-Hr-Management-In-Organizations.pdf

MMC Venture (2019). *The state of AI: Divergence.* https://www.stateofai2019.com

Montealegre, R., & Cascio, W. F. (2017). Technology-driven changes in work and employment. *Communications of the ACM, 60*(12), 60-67. https://cacm.acm.org/magazines/2017/12/223043-technology-driven-changes-in-work-and-employment/fulltext

Moore, P. V. (2018a). *The quantified self in precarity: Work, technology and what counts*. Routledge.

Moore, P. V. (2018b). *The threat of physical and psychosocial violence and harassment in digitalized work*. International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---actrav/documents/publication/wcms_617062.pdf

Newman, D. (2017, November 28). *How to drive employee engagement with workplace gamification.* Forbes. https://www.forbes.com/sites/danielnewman/2017/11/28/how-to-drive-employee-engagement-with-workplace-gamification/

Noble, S. U. (2018). *Algorithms of oppression: How search engines reinforce racism.* New York University Press.

Norwegian Government Security and Service Organisation (n.d.). *The National Strategy for Artificial Intelligence*. https://www.regjeringen.no/en/dokumenter/nasjonal-strategi-for-kunstig-intelligens/id2685594/?ch=7

O'Connor, S. (2016, September 8). When your boss is an algorithm. *Financial Times*. https://www.ft.com/content/88fdc58e-754f-11e6-b60a-de4532d5ea35

O'Donovan, P. (2018). *An industrial analytics methodology and fog computing cyber-physical system for Industry 4.0 embedded machine learning applications* [Doctoral dissertation , University College Cork]. Cork Open Research Archive . https://cora.ucc.ie/handle/10468/6574

OECD (2016). Big data: Bringing competition policy to the digital era. *Background note by the Secretariat.* https://one.oecd.org/document/DAF/COMP(2016)14/en/pdf

OECD (2019). *Artificial intelligence in society*. OECD Publishing. https://www.oecd.org/publications/artificial-intelligence-in-society-eedfee77-en.htm

Oliver, H. (2002). Email and internet monitoring in the workplace: Information privacy and contracting-out. *Industrial Law Journal, 31*(4), 321-352. https://doi.org/10.1093/ilj/31.4.321

Oostveen, M. (2016). Identifiability and the applicability of data protection to big data. *International Data Privacy Law, 6*(4), 299-309. https://doi.org/10.1093/idpl/ipw012

Oracle (2019). *From fear to enthusiasm: Artificial intelligence is winning more hearts and minds in the workplace.* https://www.oracle.com/webfolder/s/assets/ebook/ai-work/index.html

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

Organise (2018). *Amazon: What's it like where you work? Findings from the Amazon Warehouse Employee survey, London.* Oracle. https://static1.squarespace.com/static/5a3af3e22aeba594ad56d8cb/t/5ad098b3562fa7b8c90d5e1b/1523620020369/Amazon+Warehouse+Staff+Survey+Results.pdf

OrgVue (2019). *Making people count. 2019 report on workforce analytics. Technical report.* https://www.orgvue.com/resources/research-report/making-people-count-report/

Pakes, A. (2020, February 17). *Why big data is becoming the front line in the battle for workers' rights.* Left Foot Forward. https://leftfootforward.org/2020/02/how-big-data-is-now-the-front-line-in-workers-rights/

Partnoy, F. (2018). *What your boss could learn by reading the whole company's emails.* The Atlantic. https://www.theatlantic.com/magazine/archive/2018/09/the-secrets-in-your-inbox/565745/

Pasquale, F. (2015). *The black box society: The secret algorithms that control money and information*. Harvard University Press.

PEGA (2020). *The future of work. New perspectives on disruption & transformation*. https://www.pega.com/system/files/resources/2021-04/pega-future-of-work-report.pdf

Pérez del Prado, D. (2021). The legal framework of platform work in Spain: The new Spanish "Riders' Law". *Comparative Labor Law & Policy Journal*, Dispatch No. 36 – Spain. https://cllpj.law.illinois.edu/content/dispatches/2021/Dispatch-No.-36.pdf

Phillips-Wren, G. (2012). AI tools in decision making support systems: A review. *International Journal on Artificial Intelligence Tools, 21*(2), Article 1240005. https://doi.org/10.1142/S0218213012400052

Pindur, W., Rogers, S. E., & Kim, P. S. (1995). The history of management: A global perspective. *Journal of Management History, 1*(1), 59-77. https://doi.org/10.1108/13552529510082831

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://ssrn.com/abstract=3873786

Porter, B. (2020). *Amazon introduces 'Distance Assistant'.* Amazon. https://www.aboutamazon.com/news/operations/amazon-introduces-distance-assistant

Privacy International (2017). *Data is power: Profiling and automated decision-making in GDPR.* https://privacyinternational.org/sites/default/files/2018-04/Data%20Is%20Power-Profiling%20and%20Automated%20Decision-Making%20in%20GDPR.pdf

Provenzano, B. (2021, June 22). *Google is exploring post-pandemic remote work options for employees*. Gizmodo. https://gizmodo.com/google-is-exploring-post-pandemic-remote-work-options-f-1847153843

Pryor, M. G., & Taneja, S. (2010). Henri Fayol, practitioner and theoretician – Revered and reviled. *Journal of Management History, 16*(4), 489-503. https://doi.org/10.1108/17511341011073960

Publicis Groupe (2018). *Publicis Groupe and Microsoft announce partnership for Marcel AI Platform.* Publicis Groupe. https://www.publicisgroupe.com/sites/default/files/press-release/Press_Release_PG_MSFT_290118_DEF.pdf

Punnoose, R., & Ajit, P. (2016). Prediction of employee turnover in organizations using machine learning algorithms. *International Journal of Advanced Research in Artificial Intelligence, 5*(9), 22-26. http://dx.doi.org/10.14569/IJARAI.2016.050904

PwC (2017). *Artificial intelligence in HR: A no-brainer*. https://www.pwc.nl/nl/assets/documents/artificial-intelligence-in-hr-a-no-brainer.pdf

PwC (2019). *A virtual partnership? How artificial intelligence will disrupt project management and change the role of project managers*.

https://www.pwc.com/m1/en/publications/documents/virtual-partnership-artificial-ntelligence-disrupt-project-management-change-role-project-managers-final.pdf

Raghavan, M., Barocas, S., Kleinberg, J., & Levy, K. (2020). Mitigating bias in algorithmic hiring: Evaluating claims and practices. In *Proceedings of the 2020 Conference on Fairness, Accountability, and Transparency* (pp. 469-481). https://doi.org/10.1145/3351095.3372828

Rallyware. (2017, November 21). *Gamification powered by machine learning is the "secret sauce" for learning and development*. Medium. https://medium.com/@RallywareSF/gamification-powered-by-machine-learning-is-the-secret-sauce-for-learning-and-development-856fcc792400

Rasmussen, T., & Ulrich, D. (2015). Learning from practice: How HR analytics avoids being a management fad. *Organizational Dynamics, 44*(3), 236-242. https://doi.org/10.1016/j.orgdyn.2015.05.008

REaD Group (2021). *SME and data quality GDPR and customer data in UK SMEs.* https://readgroup.co.uk/wp-content/uploads/2021/08/SME-research-2021.pdf

Reim, W., Åström, J., & Eriksson, O. (2020). Implementation of artificial intelligence (AI): A roadmap for business model innovation. *AI, 1*(2), 180-191. https://doi.org/10.3390/ai1020011

Richman, N. (2015). Human resource management and human resource development: Evolution and contributions. *Creighton Journal of Interdisciplinary Leadership, 1*(2), 120-129. http://hdl.handle.net/10504/109172

Robbins, S. P., & Coulter, M. K. (2018). *Management* (14th ed.) Pearson.

Roose, K. (2019, June 23). A machine may not take your job, but one could become your boss. *The New York Times*. https://www.nytimes.com/2019/06/23/technology/artificial-intelligence-ai-workplace.html

Ruohonen, J., & Hjerppe, K. (2021). The GDPR enforcement fines at glance. *Information Systems, 106*, Article 101876. https://doi.org/10.1016/j.is.2021.101876

Russell, S., & Norvig, P. (2020). *Artificial intelligence: A modern approach*. Pearson.

Santoro, A., Lampinen, A., Mathewson, K., Lillicrap, T., & Raposo, D. (2021). Symbolic behaviour in artificial intelligence. *arXiv preprint arXiv:2102.03406*. https://arxiv.org/abs/2102.03406

Satariano, A. (2021, April 22). Europe proposes strict rules for artificial intelligence. *The New York Times*. https://www.nytimes.com/2021/04/16/business/artificial-intelligence-regulation.html

Savignac, E. (2019). *La gamification du travail: L'ordre du jeu*. ISTE Group.

Schweyer, A. (2018, August 27). *Predictive analytics and artificial intelligence in people management*. Incentive Research Foundation. https://theirf.org/research/predictive-analytics-and-artificial-intelligence-in-people-management/2527/

Serpa, S., & Ferreira, C. M. (2019). The concept of bureaucracy by Max Weber. *International Journal of Social Science Studies, 7*(2), 12-18. https://doi.org/10.11114/ijsss.v7i2.3979

Sharma, N., Sharma, R., & Jindal, N. (2021). Machine learning and deep learning applications-A vision. *Global Transitions Proceedings, 2*(1), 24-28. https://doi.org/10.1016/j.gltp.2021.01.004

Sheerman, L., Marston, H. R., Musselwhite, C., & Morgan, D. (2020). COVID-19 and the secret virtual assistants: The social weapons for a state of emergency. *Emerald Open Research, 2*(19). https://doi.org/10.35241/emeraldopenres.13571.1

Shpakova, A., Dörfler, V., & MacBryde, J. (2017). Changing the game: a case for gamifying knowledge management. *World Journal of Science, Technology and Sustainable Development, 14*(2/3), 143-154. https://doi.org/10.1108/WJSTSD-01-2017-0002

Slichter, S. H. (1919). *The turnover of factory labor*. Appleton.

Sostero, M., Milasi, S., Hurley, J., Fernandez-Macias, E., & Bisello, M. (2020). Teleworkability and the COVID-19 crisis: A new digital divide? *JRC Working Papers Series on Labour, Education and Technology 2020/05*. A Joint European Commission–Eurofound Report. https://ec.europa.eu/jrc/sites/default/files/jrc121193.pdf

Speer, A. B. (2020). Scoring dimension-level job performance from narrative comments: Validity and generalizability when using natural language processing. *Organizational Research Methods, 24*(3), 572-594. https://doi.org/10.1177%2F1094428120930815

Strickland, E. (2019). IBM Watson, heal thyself: How IBM overpromised and underdelivered on AI health care. *IEEE Spectrum, 56*(4), 24-31. https://doi.org/10.1109/MSPEC.2019.8678513

Sullivan, G. M., & Artino Jr, A. R. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Medical Education, 5*(4), 541-542. https://dx.doi.org/10.4300%2FJGME-5-4-18

Sun, N. (2021, June 15). China's tech workers pushed to their limits by surveillance software. *Financial Times*. https://www.ft.com/content/b74b6ad6-3b8d-4cd8-9dd6-3b49754aa1c7

Tabassum, F., & Ghosh, N. (2018). Future of performance management in artificial intelligence ERA. *International Journal of Arts, Science and Humanities, 6*(S1), 7-14. https://doi.org/10.5281/zenodo.1469447

Tambe, P., Cappelli, P., & Yakubovich, V. (2019). Artificial intelligence in human resources management: Challenges and a path forward. *California Management Review, 61*(4), 15-42. https://doi.org/10.1177/0008125619867910

Tegmark, M. (2017). *Life 3.0: Being human in the age of artificial intelligence*. Knopf.

Teh, C. (2021, June 16). *'Every smile you fake' — An AI emotion-recognition system can assess how 'happy' China's workers are in the office*. Insider. https://www.insider.com/ai-emotion-recognition-system-tracks-how-happy-chinas-workers-are-2021-6#:~:text='Every%20smile%20you%20fake'

The Federal Council of Switzerland (2020). *Guidelines for artificial intelligence*. https://www.sbfi.admin.ch/sbfi/de/home/aktuell/medienmitteilungen/news-anzeige-nsb.msg-id-81319.html

The German Federal Government's Artificial Intelligence (2018). Germany: Artificial Intelligence Strategy. https://ai-watch.ec.europa.eu/countries/germany/germany-ai-strategy-report_en

Thomson Reuters. (2019). *GDPR+1 YEAR: Business struggles with data privacy regulations increasing.* http://ask.legalsolutions.thomsonreuters.info/GDPR1YearBusinessStrugglesReport

Till, C. (2016, April 6). *Why do companies want us to be healthy? Corporate wellness, self-tracking and philanthrocapitalism.* This is Not a Sociology Blog. https://christopherharpertill.wordpress.com/2016/04/06/why-do-companies-want-us-to-be-healthy-corporate-wellness-self-tracking-and-philanthrocapitalism/

Todoli-Signes, A. (2020). Complying with the first law of robotics: An analysis of the occupational risks associated with work directed by an algorithm/artificial intelligence. *SSRN Electronic Journal*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3522406

Truss, C., Shantz, A., Soane, E., Alfes, K., & Delbridge, R. (2013). Employee engagement, organisational performance and individual well-being: Exploring the evidence, developing the theory. *The International Journal of Human Resource Management, 24*(14), 2657-2669. https://doi.org/10.1080/09585192.2013.798921

Urzì Brancati, M. C. and Curtarelli, M. (2021) Digital tools for worker management and psycho-social risks in the workplace: evidence from the ESENER survey in *JRC Working Papers on Labour, Education and Technology from Joint Research Centre No 2021-12*. https://joint-research-centre.ec.europa.eu/publications/digital-tools-worker-management-and-psycho-social-risks-workplace-evidence-esener-survey_en

Valle, M. A., & Ruz, G. A. (2015). Turnover prediction in a call center: Behavioral evidence of loss aversion using random forest and naïve bayes algorithms. *Applied Artificial Intelligence, 29*(9), 923-942. https://doi.org/10.1080/08839514.2015.1082282

van der Wolk, A. (2021, June 25). *How to prepare for a new era of AI regulation.* Tech Monitor. https://techmonitor.ai/technology/ai-and-automation/how-to-prepare-for-a-new-era-of-ai-regulation-eu

Vedapradha, R., Hariharan, R., & Shivakami, R. (2019). Artificial intelligence: A technological prototype in recruitment. *Journal of Service Science and Management, 12*(3), 382-390. https://doi.org/10.4236/jssm.2019.123026

Villani, C. (2018). *For a meaningful artificial intelligence. Towards a French and European strategy.* https://www.aiforhumanity.fr/pdfs/MissionVillani_Report_ENG-VF.pdf

Vrontis, D., Christofi, M., Pereira, V., Tarba, S., Makrides, A., & Trichina, E. (2021). Artificial intelligence, robotics, advanced technologies and human resource management: A systematic review. *The International Journal of Human Resource Management, 33*(6), 1237-1266. https://doi.org/10.1080/09585192.2020.1871398

Wang, P. (2019). On defining artificial intelligence. *Journal of Artificial General Intelligence, 10*(2), 1-37. https://doi.org/10.2478/jagi-2019-0002

Wachter, S., & Mittelstadt, B. (2018). A right to reasonable inferences: Re-thinking data protection law in the age of big data and AI. *Columbia Business Law Review*, *2019*, 494-620. https://academiccommons.columbia.edu/doi/10.7916/d8-mvax-p446/download

Wawrzyniak, B., & Zygmuntowski, J. J. (2020). *Cyfrowy tayloryzm: globalne spółki cyfrowe a nadzór nad pracownikami i MŚP*. https://orka.sejm.gov.pl/opinie9.nsf/nazwa/648_20201026/$file/648_20201026.pdf

Weissbrot, A. (2021, December 7). *Publicis Groupe plots return to the office, with help from Marcel*. PR Week. https://www.prweek.com/article/1712902/publicis-groupe-plots-return-office-help-marcel

Wiseman, B. (2021, March 22). *The next great disruption is hybrid work – Are we ready?* https://www.microsoft.com/en-us/worklab/work-trend-index/hybrid-work

Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering - EASE '14*, Article 38, 1-10. https://doi.org/10.1145/2601248.2601268

World Economic Forum (2018). *How to prevent discriminatory outcomes in machine learning*. World Economic Forum Global Future Council on Human Rights 2016-2018. http://www3.weforum.org/docs/WEF_40065_White_Paper_How_to_Prevent_Discriminatory_Outcomes_in_Machine_Learning.pdf

WP29 (Article 29 Working Party) (2017). *Opinion 2/2017 on data processing at work', 8 June.* https://ec.europa.eu/newsroom/article29/items/610169

Wright, J. (2021, May 24). *'AI' is being used to profile people from their head vibrations – But is there enough evidence to support it?* The Conversation. https://theconversation.com/ai-is-being-used-to-profile-people-from-their-head-vibrations-but-is-there-enough-evidence-to-support-it-160566

Wujciak, M. (2019, October 18). *4 Companies using machine learning to keep a close eye on employees*. CCW Digital. https://www.customercontactweekdigital.com/tools-technologies/articles/4-companies-using-machine-learning-to-keep-a-close-eye-on-employees

Yogeeswaran, K., Złotowski, J., Livingstone, M., Bartneck, C., Sumioka, H., & Ishiguro, H. (2016). The interactive effects of robot anthropomorphism and robot ability on perceived threat and support for robotics research. *Journal of Human-Robot Interaction, 5*(2), 29-47. https://doi.org/10.5898/JHRI.5.2.Yogeeswaran

Yedla, A., Kakhki, F. D., & Jannesari, A. (2020). Predictive modeling for occupational safety outcomes and days away from work analysis in mining operations. *International Journal of Environmental Research and Public Health, 17*(19), Article 7054. https://doi.org/10.3390/ijerph17197054

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). https://doi.org/10.1109/AI4G50087.2020.9311088

Zhang, H., Xu, L., Cheng, X., Chao, K., & Zhao, X. (2018), September. Analysis and prediction of employee turnover characteristics based on machine learning. In *2018 18th International Symposium on Communications and Information Technologies (ISCIT),* 371-376. https://doi.org/10.1109/ISCIT.2018.8587962

Ziewitz, M. (2015). Governing algorithms: Myth, mess, and methods. *Science, Technology, & Human Values, 41*(1), 3-16. https://doi.org/10.1177/0162243915608948

Zwetsloot, G. I. J. M. (2014). *What are occupational safety and health management systems and why do companies implement them?* https://oshwiki.eu/wiki/What_are_occupational_safety_and_health_management_systems_and_why_do_companies_implement_them%3F

7 Annex I – Key definitions

Table I-1: Key definitions

Concepts	Definitions
AI-based worker management (AIWM)	AI-based worker management (AIWM) refers to a worker management system that gathers data, often in real time, on the workspace, workers and the work they do, 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 (European Parliamentary Research Services, 2020a; EU-OSHA, 2019). It also includes algorithmic management, but it can be considered more advanced than the former as it allows to automate tasks that are cognitive in nature (e.g. worker monitoring through face recognition software, creating robots that can track the mental health of employees, predict which employees might leave the organisation soon).
Algorithm	An explicitly defined set of instructions describing how a computer, or a human, could perform an action, task or procedure, and solve a problem (Dourish, 2016; Muldner & Shakshuki, 2018).
Algorithmic management	A subtype of AIWM where simple (i.e. without 'intelligence') algorithms and digital technologies (e.g. worker monitoring devices, computers, face recognition software) are used to manage workers in an automated or semi-automated manner (Mateescu & Nguyen, 2019). It provides the means to automate large numbers of worker management activities (e.g. schedule making, shift making, worker monitoring through wearable devices).
Artificial Intelligence (AI)	'Aims to be as technology neutral and future proof as possible.' It describes AI, or more specifically AI systems, as (European Commission, 2021, p. 39): '"artificial intelligence system" (AI system) means software that is developed with one or more of the techniques and approaches listed in Annex I [of the proposal] and can, for a given set of human-defined objectives, generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with'. [78]
Automation	Based on Parasuraman et al. (2000, p. 287), automation is: 'a device or system that accomplishes (partially or fully) a function that was previously, or conceivably could be, carried out (partially or fully) by a human.'
Big data	Datasets characterised by volume (large size), velocity (constantly growing), and variety (structured and unstructured form such as texts), which is often used by AI machines (OECD, 2016).
Data analytics	A process of extracting insights and knowledge from data using statistical or other techniques and tools (Gandomi & Haider, 2015).
Deep learning	Branch of machine learning that uses (artificial) neutral networks to mimic a human brain and to improve AI learning capabilities (Goodfellow et al., 2017; Sharma et al., 2021).

[78] Alternatively, AI systems can be defined based on the High-Level Expert Group on Artificial Intelligence (2019a) as: 'software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal'.

Concepts	Definitions
Machine learning	Branch of AI dealing with how computers can learn, grow and improve on their own from data without human intervention (Goodfellow et al., 2017; Sharma et al., 2021).
People/worker analytics	A subset of data analytics, which involves analysis of employee data that are used to 'measure, report and understand employee performance, aspects of workforce planning, talent management and operational management' (Collins et al., 2017, cited in EU-OSHA, 2019, p. 3.). In recent years it started to be more frequently integrated with AI.
Semi- and fully automated decisions	Semi-automated decision-making refers to human decisions supported by results of automated computer algorithms (with or without AI integration), while fully automated decision-making refers to giving full autonomy to computer algorithms to make decisions (Deobald et al., 2019; Köchling & Wehner, 2020).
Worker management	A process of overseeing and governing employees to better achieve organisational goals, such as increase productivity, efficiency and decrease employee turnover (Koontz & O'Donnell, 1955; Richman, 2015). It is a process of worker organisation, which might include, but is not limited to, worker monitoring, worker surveillance, control, and reward/punishment systems.
Worker monitoring	The practice of capturing information on employees, such as their location, wellbeing and current task, with a goal to track performance, make sure no employees are violating company policies, and identify health issues or safety risks (Eurofound, 2020b; EU-OSHA, 2017).
Worker surveillance	A more intrusive worker tracking extending beyond work, including such activities as tracking social media posts and different websites visits (Edwards et al., 2019; McNall & Stanton, 2011, cited in Eurofound, 2020b). The main aim of worker surveillance is to gather as much information on workers as possible to make sure, for example, that workers comply with their contractual obligations, checking if the opinion that employees share on social platforms is in line with company values (Edwards et al., 2019; McNall & Stanton, 2011).

8 Annex II – Examples of tools for AI-based worker management

Table II-1 presents relevant tools that are grouped based on the goals that can help organisations to achieve (that is, optimising the business process, implementing robust data-driven decision-making, improving worker health, safety and overall wellbeing) and are arranged in a descending order based on the AI type (that is, perception, comprehension, decision). It is also important to note that as can be seen in the AI type column, the majority of tools can be assigned to several AI types. This is because not all AI-based tools are created equal as by tweaking the level of AI integration in a specific tool, it can move from simply providing data to a much more sophisticated tool that can give recommendations or act on its own based on the best possible course of actions. In addition, tools/new forms of worker management covered in Table II-1 cover the most frequently mentioned both in the literature and by experts during interviews and do not cover everything that is possible. In addition, the discussed tools are relatively broad in nature, which means many of them also include some specific tools, which also leads to assign a single new form of worker management to several AI types.

Table II-1: New forms of AI-based worker management

Tools	Short description	How the system is used
Optimising the business process		
AI-based problem detection	Identifying work-related problems, such as too many failures during product inspection, operations taking too long, diminished wellbeing of workers (BellHawk, 2016). This approach is heavily interconnected with worker monitoring and surveillance. However, in addition to such giving employers tools to know what workers are doing, identify issues relatively fast and find employees strengths, it also brings a lot of negatives to workers, such as leading workers to feel stress and anxiety due to micromanagement and constantly being watched Eurofound (2020b).	**Perception** – identifies and informs managers of business-related problems.
Automated scheduling and task allocation	Approaches that automate, and sometimes improve, the scheduling and task allocation process in the company using AI approaches. Such approaches can be used to, for example, predict the demand from customers so that an appropriate number of individuals can be scheduled to work (Kronos, 2018), using virtual assistants during scheduling meetings that interpret what was said and appropriately distribute work (PwC, 2019), and assign workers to tasks that match their skills (Kronos, 2018). Automated scheduling and task allocation benefit companies by speeding up and sometimes improving the scheduling process, and they benefit workers by giving them a more flexible tool for scheduling their work. However, these approaches can also have negative effects for workers, such as making some overwork if the AI model learned from discriminatory data (Benjamin, 2020; Noble, 2018) or inducing stress by taking away the worker's ability, and hence autonomy, of selecting the tasks on their own in whichever order they wish (Brione, 2020).	**Perception** – the tool only collects unstructured data on worker future activities (e.g. by listening in on meetings when work distribution is discussed) and summarises this information. **Decision** –the tool decides how to distribute the work on its own. Note, if the tool converts information from scheduling meetings into a schedule for workers, the tool cannot be necessarily considered as AI-based as a simple non-intelligent algorithm could also do this.

Optimising the business process		
Collaboration tools with AI elements	Tools that connect workers and employers and that have AI elements improving the communication between them, allowing them to better collaborate on projects, and similar. One such tool is Marcel that connects over 80,000 employees working for Publicis Groupe, a French multinational advertising company (Publicis Groupe, 2018). This tool, in addition to providing a platform that connects employees that does not necessarily require AI integration, identifies workers who can help with specific tasks, provides workers with tools to contribute to projects that might interest them, but which might be happening outside their city, country or even continent, and similar (Publicis Groupe, 2018). Though initially Marcel was met with a lot of scepticism, it helped Publicis Groupe ease the move to telework during the COVID-19 pandemic, and, by some accounts, saved over 2,000 jobs (Weissbrot, 2021). However, according to interviews, such a tool can also lead to several severe OSH-related issues, such as overwork and invasion of privacy, as these tools often force employees to be available 24/7.	**Perception** – if only connects users and automatically provides some insights about possible collaboration to both workers and employers. **Decision** – if provides recommendations to workers on what projects they could collaborate on.
Gamification	Bringing ideas and concepts from games, such as rewards for milestones, into the work environment to improve efficiency and productivity (Savignac, 2019). It can promote collaboration and interaction between teams, reduce stress and improve overall employee satisfaction in a workplace (Makanawala et al., 2013). Though often carried out without any sophisticated methods, it can be enhanced with AI through automation or by improving its capabilities, such as proposing personalised rewards for workers (Rallyware, 2017). However, it might also foster several negative OSH-related outcomes, such as making workers feel overwhelmed, stressed and fatigued due to the constant pressure to perform better, which can lead to burnouts (Newman, 2017). It can also be invasive as providing personalised rewards requires the system to gather data about employees' work patterns and behaviours, such as what motivates them (Mason, 2018).	**Comprehension** – if only provides some aggregated information on workers, such as if their engagement would increase with introduction of rewards. **Decision** – if recommendations and milestones are tailored made for each employee and the system on its own is able to decide when to provide a reward to an employee and automatically provide it.
Worker direction tools	Tools that can provide instruction, direction or guidance to workers on how to perform their task better. For example, Amazon has experimented with ultrasonic employee wristbands that emit ultrasonic sound pulses and radio transmission tracking the hand placement of employees as they retrieve items and steer them towards the right direction where they need to bring them using vibrations (Wujciak, 2019). Similarly, Barclays, a UK-based bank, uses tracking software that monitors the time workers spend at their desk, or the length of their toilet breaks, but also suggests what to do if they fall behind targets (Eurofound, 2020b). These, and similar, tools, can increase efficiency and productivity, but they can also often bring severe issues to OSH. Namely, according to Eurofound (2020b, p. 35), such systems, and others that heavily rely on worker monitoring and/or surveillance, might 'inhibit creative thinking, limit independence of thought and induce stress-related illness.' Some interviewed experts also raised privacy concerns that such micromanagement can dehumanise workers, force them to work more like machines, which, in turn, can induce stress-related ailments.	**Decision** – if provides recommendations to workers on what projects they could collaborate on.

Optimising the business process		
Digital partners/assistants	Computer software (e.g. chatbots) that can provide support for employees by answering HR related questions and help managers with worker management (Zel and Kongar, 2020). In terms of OSH, digital assistants can help with feelings of isolation (Sheerman, 2020). However, in the business environment if it replaces HR managers, they might lead to the opposite effect due to the diminished amount of human interaction. Digital assistants can further reduce the welfare of workers by always listening in on them, analysing their speech and what they write, and providing this information to managers and employers that might induce stress, anxiety, and similar feelings in workers (Lau et al., 2018).	**Decision –** mimics human assistants and is able, on its own, to decide what information to share, what instruction to provide, etc.

Implementing robust data-driven decision-making		
AI-powered worker monitoring	Worker monitoring tools that are enhanced by AI allowing them to go beyond purely monitoring worker performance to monitoring their feelings, behaviour, wellbeing, social network presence and many other things (Ball, 2021; Eurofound, 2020b; Kellogg et al., 2020). For example, face recognition, that uses AI, can enhance worker monitoring (Mateescu & Nguyen, 2019) while sentiment analysis, which also often uses AI-based tools, on worker speech patterns or their emails can be used to gauge their emotion wellbeing (Calvo et al., 2017). However, it can also create a lot of issues for workers, such as induce stress and anxiety due to the fact they are always being watched (Bell, *preprint*; Eurofound, 2020b).	**Perception** – if only used to gather relevant information on workers. **Comprehension** – if also provides some meaning to the monitoring data, such as using face recognition to assign names to monitored workers.
People/workforce analytics	An approach to analyse data on workers, such as if delivery workers did not leave their route, identify if employees are not abusing their corporate email. Though this task can be done by humans or through simple algorithms, AI might enrich it. For example, an AI-based approach can be used to analyse emails to identify unwelcome patterns (Partnoy, 2018), quantify information from text such as performance reviews (Speer, 2020), analyse the factors that lead to lower, or higher, performance of workers (Awan et al., 2020), or that lead to workers leaving (Zhang et al., 2018). Many tools fall under people analytics, including **AI-based recruiting tools** – tools that can help with recruitment by, for example, extracting information on relevant skills from CVs, cover letters and other sources of potential workers, test candidates, carry out interviews (Vedapradha et al., 2019). These approaches can heavily speed up the recruitment process and they might be less biased in the selection (Brione, 2020). However, 'less biased' is not as given as, for example, based on Fernández-Martínez and Fernández (2020), some voice analysis software are biased towards male voices and individuals without accents, AI-based tools that trained based on previous recruitment data can further exacerbate the bias present in them, and the tool could also favour individuals with more symmetric faces, which does not have any impact on job performance.	**Perception** – if only summarises the data and present them in an easy-to-use manner to human decision-makers. **Comprehension** – if provides some insights, for example, why the worker turnover is high, how it will change in the future. **Decision** – able to make decisions, such as a robot recruiting tool that can arrange interviews and tests, perform them, and based on their results decide who is the best candidate for the job.

Implementing robust data-driven decision-making		
Performance/productivity management tools	Tools that can be used to improve worker performance. For example, Status Today's – London-based IT company – tool Isaak can identify from worker interactions something called 'change makers' – employees who collaborate and engage more in a workplace (Haven, 2020). A similar tool called Enaible, created by an IT company with the same name, measures how quickly employees complete various tasks and even suggests ways to speed them up (Heaven, 2020). These, and similar AI-based tools, if used appropriately, can help to increase efficiency of workers, identify problematic employees and help with staff development (Tabassum & Ghosh, 2018). However, the highly intrusive nature of such approaches, especially from the worker monitoring/surveillance side, might create a lot of OSH-related negative effects, including, but not limited to: data bias that translates into AI model bias (Benjamin, 2020; Deobald et al., 2019; Noble, 2018), dehumanising workers, forcing them to work more like robots (Moore, 2018) and similar.	**Perception** – if the tools are purely used to get information on employees. However, as this is more connected to worker monitoring/surveillance than management, such tools are beyond the scope of this research. **Decision** – if the tools can provide recommendations and decisions shown to improve performance/productivity of workers.
AI-powered prediction models	Forecasting models that predict different factors related to workers. For example, first, AI is often used to predict who in the staff is most likely to soon leave the company and hence should receive more attention from managers (Punnose & Ajit, 2016) and what actions can be done to prevent this (Fisher, 2019). Second, they can also be used to predict who in the company has the largest potential and hence should receive more training and/or more demanding tasks (Mishra et al., 2016). Finally, combining prediction models with real-time worker monitoring can also be used to predict work accidents (Yedla et al., 2020), burnout (Grządzielewska, 2021) and similar.	**Comprehension** – if tools are used to derive predictions/forecasts that managers will later use to make decisions on their own. **Decision** – if the tool provides recommendations and decisions on how to diminish the probability of a forecast occurring (e.g. turnover of workers) or increase a probability of something happening (e.g. a worker reaching their potential).
Personalised AI-based career development tools	Training supported through AI systems that includes, but is not limited to, tools that can identify training needs based on employee performance, platforms that can propose a training provider based on personal and/or work-related needs, schedule the training and so on (Maity, 2019). From the employers' perspective, such tools can reduce the amount of resources required to train employees, while for workers such tools can provide tailor-made recommendations regarding training (Maity, 2019). However, just like the majority of AI tools that try to control workers, AI-supported training can lead to several negative effects, such as workers losing autonomy and having to follow the guidance of a tool that not all of them understand, which might lead to anxiety issues.	**Comprehension** – if the tool only identifies training needs. **Decision** – if the tool also provides decisions or recommendations in what training programmes workers should participate or prepares the training programmes itself.

Improving worker health, safety and overall wellbeing		
Health, safety and/or wellbeing issue identification and management tools	These tools can be considered a subset of the AI-based problem detection model discussed prior and it is a new form of worker management that uses AI-based tools to identify issues in the workplace related to health, safety and wellbeing, as well as mitigate them through better worker management (Belton, 2019; Till, 2016). For example, some tools can detect connections between how workers use their language and their emotional, psychological and health states (Calvo et al., 2017). Other tools are able to create health and risk profiles, though worker monitoring and/or surveillance, on which managers could act if any issues are identified (Chamorro-Premuzic, 2020). Finally, there are also several very narrow tools that were created for a very specific problem. For example, during the COVID-19 pandemic Amazon created Distance Assistant – a tool that checks if employees are maintaining social distancing and warning them if they are not (Porter, 2020).	**Perception** – if only identifies issues. However, as this is predominantly related to the domain of worker monitoring/surveillance, it will not be explored in the subsequent reports. **Decision** – if provides recommendations how to ensure a safe working environment, when employers should intervene to ensure the wellbeing of workers.
Mental health chatbots	Software robots with which workers can communicate regarding their mental health and that can analyse the communication patterns of workers to estimate probabilities of different psychosocial issues, such as burnout (Cameron et al., 2017; Oracle and Workplace Intelligence, 2020; Zel & Kongar, 2020). Some chatbots can also provide personalised mindfulness practices to at-risk workers (Zel & Kongar, 2020). Chatbots can provide a valuable tool for companies to help with workers' mental health as some of them are more inclined to talk to bots than managers. However, for this tool to be truly useful, it is crucial that managers are completely transparent about the data these tools collect and how they are used, so that the workers can feel at ease that anything they disclose is not used against them, which is a fear shared by many workers (EU-OSHA, 2019; Partnoy, 2018). Though, given that there is often lack of trust between workers and employers (Brower et al., 2009), this might be one big barrier that will lead this tool to only limited success in some organisations.	**Perception** – if only used to identify if there are any issues related to mental health. **Decision** – if also used to provide recommendations/decisions on how to improve the psychosocial health of workers.
AI-based worker engagement/job satisfaction management tools	Tools with AI elements that try to improve worker engagement and/or job satisfaction (Hughes et al., 2019). These tools are heavily utilised with gamification approaches and can be implemented in a variety of ways. First, engagement and job satisfaction can be improved by monitoring and analysing worker data to reward workers for a good job and punish those who did not meet expectations (Hughes et al., 2019). Second, identifying what 'drives' the workers and giving them more autonomy to do what they like, showing more trust in them and allowing workers to express themselves more (Schweyer, 2018). Third, better match workers with work/other workers that they enjoy doing/working with (Kronos, 2018). These are only some examples of how engagement and satisfaction of workers can be improved, but it has to be mentioned that all of them can also be implemented without AI. However, the usage of AI might improve these tools by allowing to derive insights from large worker monitoring/surveillance datasets as well as improve the effectiveness of these approaches as AI-based tools can evolve and improve with more data (Hughes et al., 2019).	**Decision** – if provides information and recommendations on what to do to improve engagement/job satisfaction of workers.

9 Annex III – European Survey of Enterprises on New and Emerging Risks 2019 (ESENER-3) analysis

The questionnaire for ESENER-3, the third wave of EU-OSHA's establishment survey on safety and health at work conducted in 2019, covers a broad scope of 'traditional' and psychosocial risks and the way that they are managed at the organisational level. It also contains several questions covering the implementation of different technologies that can be connected to worker management and how they affect OSH.

The analysis of ESENER-3 data reported here focuses on analysing Q310: 'Does your establishment use any of the following digital technologies for work?' This question provides insights on different technologies that workplaces might be using, including: (i) personal computers; (ii) laptops, tablets, other mobile computer devices; (iii) robots that interact with workers; (iv) machines or similar determining the content or pace of work; (v) machines or similar monitoring workers' performance; and (vi) wearable devices, such as smart watches. Though in theory all of these technologies can enable AIWM, many workplaces use computers and laptops without any AI integration. Hence, in the analysis we predominantly focus on the last four technologies as they provide much better proxies for AIWM, while usage of computers and laptops is explored where relevant. Table III-1 provides the distribution of answers in raw terms, which indicates the sample size.

Table III-1: Workplaces that use digital technologies by type of technology (EU-27, 2019 - N)

Types of technology used (ESENER-3 Q310 answers)	Does your establishment use any of the following digital technologies for work? Yes	No	TOTAL
Personal computers at fixed workplaces	32,317	5,084	**37,401**
Laptops, tablets, smartphones or other mobile computer devices	31,088	6,338	**37,426**
Robots that interact with workers	1,993	35,376	**37,369**
Machines, systems or computers determining the content or pace of work	5,594	31,655	**37,249**
Machines, systems or computers monitoring workers' performance	4,252	33,036	**37,288**
Wearable devices, such as smart watches, data glasses or other (embedded) sensors	2,038	35,314	**37,352**

Source: Authors' calculations on ESENER-3 data.
Note: The sample size for different technologies does not match due to a not-uniform amount of non-answers.

The analysis consists of two parts: bivariate analysis and regression analysis. First, bivariate analysis provides general insights about the use of technologies that can serve as proxies for AIWM. This includes insights on all workplaces surveyed in ESENER-3 as well as on specific groups of workplaces based on country, sector, size and similar. Results from the bivariate analysis can be found in the following tables.

Table III-2: Workplaces that use digital technologies by type of technology (EU-27, 2019 - %)

Country	Personal computers at fixed workplaces	Laptops, tablets, smartphones or other mobile computer devices	Robots that interact with workers	Machines, systems or computers determining the content or pace of work	Machines, systems or computers monitoring workers' performance	Wearable devices, such as smart watches, data glasses or other (embedded) sensors
AT	90%	78%	4%	11%	4%	9%
BE	86%	83%	4%	11%	12%	3%
BG	82%	70%	4%	9%	22%	4%
CY	93%	70%	1%	14%	8%	3%
CZ	93%	92%	7%	8%	8%	5%
DE	93%	80%	2%	11%	6%	7%
DK	68%	85%	7%	17%	16%	5%
EE	87%	82%	2%	7%	7%	3%
EL	93%	76%	2%	22%	9%	4%
ES	87%	74%	4%	15%	8%	6%
FI	81%	92%	3%	19%	23%	3%
FR	75%	70%	5%	9%	10%	2%
HR	94%	92%	5%	12%	7%	4%
HU	95%	87%	3%	24%	11%	8%
IE	74%	78%	5%	18%	18%	6%
IT	94%	62%	3%	11%	5%	2%
LT	73%	89%	4%	9%	20%	7%
LV	83%	82%	4%	9%	11%	6%

Country	Personal computers at fixed workplaces	Laptops, tablets, smartphones or other mobile computer devices	Robots that interact with workers	Machines, systems or computers determining the content or pace of work	Machines, systems or computers monitoring workers' performance	Wearable devices, such as smart watches, data glasses or other (embedded) sensors
LU	78%	79%	3%	12%	9%	3%
MT	87%	84%	4%	25%	12%	3%
NL	89%	82%	3%	12%	6%	5%
PL	89%	78%	4%	7%	9%	3%
PT	55%	71%	4%	12%	8%	4%
RO	74%	88%	4%	17%	9%	9%
SE	84%	92%	3%	11%	10%	6%
SI	94%	87%	6%	13%	7%	4%
SK	91%	82%	9%	9%	8%	5%

Source: Authors' calculations on ESENER-3 data.
Note: Data was weighted using the estex variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).

Table III-3: Workplaces that use digital technologies by type of technology and economic sector (EU-27, 2019 - %)

Economic sector (NACE Rev. 2)	Personal computers at fixed workplaces	Laptops, tablets, smartphones or other mobile computer devices	Robots that interact with workers	Machines, systems or computers determining the content or pace of work	Machines, systems or computers monitoring workers' performance	Wearable devices, such as smart watches, data glasses or other (embedded) sensors
A	81%	69%	9%	19%	10%	5%
B	87%	84%	7%	14%	11%	4%
C	87%	71%	9%	23%	10%	4%
D	90%	88%	3%	13%	9%	9%
E	95%	86%	6%	14%	13%	3%
F	86%	81%	3%	9%	5%	5%
G	87%	74%	3%	11%	10%	5%
H	87%	81%	3%	16%	17%	8%
I	66%	55%	2%	11%	6%	3%
J	93%	95%	3%	14%	9%	9%
K	93%	83%	3%	11%	17%	5%
L	93%	86%	2%	7%	5%	5%
M	92%	86%	3%	9%	6%	6%
N	90%	85%	2%	11%	9%	5%
O	93%	77%	1%	7%	4%	4%
P	88%	83%	3%	5%	3%	3%
Q	89%	79%	2%	10%	6%	4%
R	90%	83%	1%	9%	5%	5%
S	84%	77%	2%	7%	6%	4%

Source: Authors' calculations on ESENER-3 data.
Note: Data was weighted using the estex variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).
Note: NACE Rev. 2 sectors: A – Agriculture, Forestry and Fishing; B – Mining and Quarrying; C – Manufacturing; D – Electricity, Gas, Steam and Air Conditioning Supply; E – Water Supply; Sewerage, Waste Management and Remediation Activities; F – Construction; G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H – Transportation and Storage; I – Accommodation and Food Service Activities; J – Information and Communication; K – Financial and Insurance Activities; L – Real Estate Activities; M – Professional, Scientific and Technical Activities; N – Administrative and Support Service Activities; O – Public Administration and Defence, Compulsory Social Security; P – Education; Q – Human Health and Social Work Activities; R – Arts, Entertainment and Recreation; S – Other Service Activities.

Table III-4: Workplaces that use digital technologies by type of technology and specific characteristics of the workplace (EU-27, 2019 - %)

Variables	Personal computers at fixed workplaces	Laptops, tablets, smartphones or other mobile computer devices	Robots that interact with workers	Machines, systems or computers determining the content or pace of work	Machines, systems or computers monitoring workers' performance	Wearable devices, such as smart watches, data glasses or other (embedded) sensors
Number of workers:						
5-9	83%	69%	3%	9%	6%	4%
10-49	89%	81%	4%	13%	9%	5%
50-249	93%	92%	7%	17%	12%	6%
250+	95%	95%	13%	26%	19%	11%
Organisation type:						
Public	88%	80%	3%	8%	6%	4%
Private	86%	76%	4%	12%	9%	5%
Employee representation:						
Work council	90%	83%	5%	15%	12%	6%
Trade union representative	88%	85%	6%	16%	14%	5%
Health and safety committee	89%	86%	6%	14%	13%	6%
Health and safety rep.	90%	80%	4%	13%	9%	6%
No representative	79%	70%	3%	9%	7%	3%

Source: Authors' calculations on ESENER-3 data.
Note: Data was weighted using the estex variable, which is: 'extrapolation to the universe of establishments in the countries covered by the survey' (EU-OSHA, 2020b, p. 81).

Second, regression analysis was used to provide a more robust analysis of how different factors impact the usage of different AIWM adjacent technologies. For the research, we used logistic regression as the variables on different technological use, which are the dependent variables in the regression, are categorical in nature. It was selected instead of simple bivariate regressions, probit, tobit or similar models, as the results from logistic regressions are easy to interpret.

In total, two groups of regression models were calculated to explore how different factors, such as workplace country of origins, size and sector. In the first model we explore how different factors affect if a company uses at least one of the technologies that we associated with AIWM[79]. Hence, the results indicate what factors lead to a larger likelihood (or more precisely odds ratio) that a workplace is utilising AIWM. Results from this regression analysis can be found in Table III-5.

To further add robustness to the research, a second group of models was calculated to explore how the same factors that were used in the first model affect the probability of workplaces employing each technology separately. The results from these models are summarised in Table III-6.

Table III-5: Logit regression results indicating how different factors affect the use of at least one of the selected four digital technologies[80]

	Variables	Coefficient	EXP(Coeff.)	Std. error	z	p-value	
Constant		-1.512	0.220	0.137	-11.030	<0.001	***
Country codes (Reference category: LU)	AT	0.090	1.094	0.118	0.759	0.448	
	BE	-0.004	0.996	0.117	-0.038	0.970	
	BG	0.348	1.416	0.132	2.643	0.008	***
	CY	0.208	1.231	0.138	1.504	0.133	
	CZ	-0.046	0.955	0.117	-0.395	0.693	
	DE	0.002	1.002	0.113	0.019	0.985	
	DK	0.710	2.034	0.119	5.960	<0.001	***

[79] Robots that interact with workers; Machines, systems or computers determining the content or pace of work; Machines, systems or computers monitoring workers' performance; Wearable devices, such as smart watches, data glasses or other (embedded) sensors.
[80] The four technologies selected here are those that are to an extent connected to AI and AIWM: (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.

	Variables	Coefficient	EXP(Coeff.)	Std. error	z	p-value	
	EE	-0.785	0.456	0.150	-5.226	<0.001	***
	EL	0.439	1.552	0.118	3.710	<0.001	***
	ES	0.186	1.205	0.111	1.675	0.094	*
	FI	0.723	2.061	0.114	6.367	<0.001	***
	FR	-0.160	0.852	0.113	-1.423	0.155	
	HR	-0.061	0.941	0.135	-0.450	0.653	
	HU	0.646	1.907	0.115	5.591	<0.001	***
	IE	0.595	1.813	0.117	5.078	<0.001	***
	IT	-0.363	0.696	0.115	-3.157	0.002	***
	LT	0.496	1.642	0.130	3.829	<0.001	***
	LV	0.072	1.075	0.137	0.526	0.599	
	MT	0.615	1.849	0.146	4.223	<0.001	***
	NL	0.101	1.107	0.121	0.841	0.401	
	PL	-0.276	0.759	0.115	-2.405	0.016	**
	PT	-0.043	0.958	0.118	-0.364	0.716	
	RO	0.112	1.118	0.116	0.963	0.336	
	SE	0.379	1.460	0.117	3.231	0.001	***
	SI	-0.115	0.892	0.124	-0.925	0.355	
	SK	0.150	1.162	0.140	1.074	0.283	
NACE Rev. 2 sectors[81] (Reference category: A)	B	-0.037	0.963	0.191	-0.195	0.845	
	C	0.291	1.338	0.090	3.252	0.001	***
	D	-0.268	0.765	0.187	-1.430	0.153	
	E	-0.230	0.795	0.139	-1.650	0.099	*
	F	-0.722	0.486	0.099	-7.323	<0.001	***
	G	-0.363	0.696	0.089	-4.073	<0.001	***
	H	-0.046	0.955	0.102	-0.449	0.654	
	I	-0.646	0.524	0.099	-6.528	<0.001	***
	J	-0.420	0.657	0.118	-3.564	<0.001	***
	K	-0.340	0.712	0.120	-2.825	0.005	***
	L	-0.753	0.471	0.144	-5.248	<0.001	***
	M	-0.536	0.585	0.103	-5.212	<0.001	***
	N	-0.599	0.550	0.105	-5.720	<0.001	***
	O	-1.053	0.349	0.114	-9.265	<0.001	***
	P	-1.122	0.326	0.104	-10.760	<0.001	***
	Q	-0.871	0.418	0.097	-8.992	<0.001	***
	R	-0.951	0.386	0.139	-6.866	<0.001	***
	S	-0.639	0.528	0.117	-5.471	<0.001	***
Company size (Reference category: 5-9)	10-49	0.325	1.384	0.034	9.632	<0.001	***
	50-249	0.705	2.025	0.043	16.470	<0.001	***
	250+	1.307	3.696	0.053	24.820	<0.001	***
Number of workers 55+ of age (none at all excluded)	Less than a quarter	-0.109	0.897	0.038	-2.879	0.004	***
	A quarter to half	-0.172	0.842	0.045	-3.813	<0.001	***
	More than half of your workforce	-0.261	0.770	0.065	-4.039	<0.001	***
Have employees who regularly work from home		0.221	1.247	0.039	5.740	<0.001	***
Perform regular risk assessment		0.160	1.174	0.039	4.094	<0.001	***
Is a public company		-0.016	0.984	0.044	-0.377	0.706	
Company arranges regular medical examinations		0.201	1.223	0.041	4.919	<0.001	***
Company was visited by the labour inspector in the past three years		0.291	1.338	0.029	10.100	<0.001	***

Source: Authors' calculations on ESENER-3 data.

Note 1: Selected 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; (iv) Wearable devices, such as smart watches, data glasses or other (embedded) sensors.

Note 2: N = 25,596.

Note 3: * indicates a statistical significance of 0.1; ** indicates a statistical significance of 0.05; *** indicates a statistical significance of 0.01.

[81] NACE Rev. 2 sectors: A – Agriculture, Forestry and Fishing; B – Mining and Quarrying; C – Manufacturing; D – Electricity, Gas, Steam and Air Conditioning Supply; E – Water Supply; Sewerage, Waste Management and Remediation Activities; F – Construction; G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H – Transportation and Storage; I – Accommodation and Food Service Activities; J – Information and Communication; K – Financial and Insurance Activities; L – Real Estate Activities; M – Professional, Scientific and Technical Activities; N – Administrative and Support Service Activities; O – Public Administration and Defence, Compulsory Social Security; P – Education; Q – Human Health and Social Work Activities; R – Arts, Entertainment and Recreation; S – Other Service Activities.

	Variables	Coefficient	EXP(Coeff.)	Std. error	z	p-value

Note 4: Robust quasi-maximum likelihood robust standard error was applied to ensure robustness.
Note 5: There was no collinearity issues in the model (all coefficients had a Variance Inflation Factor below 10).

Table III-6: Logit regression results indicating how different factors affect the use of one of the four technologies (usage of technology equals 1 in the regression)

	Variables	Robots that interact with workers (1 = yes)	Machines, systems or computers determining the content or pace of work (1 = yes)	Machines, systems or computers monitoring workers' performance (1 = yes)	Wearable devices, such as smart watches, data glasses or other (embedded) sensors (1 = yes)
Constant		0.027***	0.136***	0.055***	0.019***
Country codes (Reference category: LU)	AT	0.861	0.844	0.472***	3.69***
	BE	0.928	0.811	1.531***	1.087
	BG	0.76	0.594***	2.969***	1.559
	CY	0.348***	1.661***	1.187	0.994
	CZ	1.273	0.661***	1.062	1.304
	DE	0.586**	0.86	0.69**	2.41***
	DK	2.584***	1.686***	2.318***	1.9**
	EE	0.461**	0.412***	0.947	0.961
	EL	0.678	2.092***	1.242	1.205
	ES	1.008	1.219	1.091	2.191***
	FI	0.925	1.67***	3.657***	1.123
	FR	1.058	0.694**	1.258	0.695
	HR	0.841	0.902	0.844	1.46
	HU	0.591**	2.197***	1.552***	3.206***
	IE	1.184	1.915***	2.468***	1.754**
	IT	0.809	0.73**	0.645**	0.952
	LT	0.641	0.62***	3.208***	2.6***
	LV	0.939	0.684**	1.541**	1.705*
	MT	0.945	2.261***	1.69**	1.359
	NL	0.922	1.119	0.87	1.802**
	PL	0.754	0.571***	1.219	1.02
	PT	0.725	0.853	1.09	1.897***
	RO	0.628**	1.063	0.846	2.745***
	SE	1.232	1.092	1.64***	2.334***
	SI	1.23	0.853	0.9	0.909
	SK	1.813**	0.846	1.345	1.547
NACE Rev. 2 sectors[82] (Reference category: A)	B	0.8	0.968	0.898	1.023
	C	1.405**	1.504***	1.205	0.832
	D	0.38***	0.694	0.659	1.745*
	E	0.532**	0.712**	1.129	0.804
	F	0.393***	0.426***	0.538***	1.139
	G	0.541***	0.586***	1.065	0.92
	H	0.34***	0.769**	1.835***	1.379*
	I	0.334***	0.55***	0.687***	0.759
	J	0.544***	0.52***	0.822	1.35
	K	0.748	0.416***	1.56***	0.703
	L	0.355***	0.499***	0.486***	0.904
	M	0.57***	0.443***	0.644***	1.215
	N	0.312***	0.485***	0.922	0.758
	O	0.157***	0.33***	0.497***	0.744
	P	0.451***	0.263***	0.296***	0.686*
	Q	0.371***	0.367***	0.5***	0.724*
	R	0.215***	0.377***	0.496***	0.599*
	S	0.358***	0.474***	0.766	0.873

[82] NACE Rev. 2 sectors: A – Agriculture, Forestry and Fishing; B – Mining and Quarrying; C – Manufacturing; D – Electricity, Gas, Steam and Air Conditioning Supply; E – Water Supply; Sewerage, Waste Management and Remediation Activities; F – Construction; G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H – Transportation and Storage; I – Accommodation and Food Service Activities; J – Information and Communication; K – Financial and Insurance Activities; L – Real Estate Activities; M – Professional, Scientific and Technical Activities; N – Administrative and Support Service Activities; O – Public Administration and Defence, Compulsory Social Security; P – Education; Q – Human Health and Social Work Activities; R – Arts, Entertainment and Recreation; S – Other Service Activities.

	Variables	Robots that interact with workers (1 = yes)	Machines, systems or computers determining the content or pace of work (1 = yes)	Machines, systems or computers monitoring workers' performance (1 = yes)	Wearable devices, such as smart watches, data glasses or other (embedded) sensors (1 = yes)
Company size (Reference category: 5-9)	10-49	1.265***	1.373***	1.505***	1.298***
	50-249	1.966***	1.955***	2.285***	1.617***
	250+	4.277***	3.204***	3.566***	2.874***
Number of workers 55+ of age (Reference category: none at all)	Less than a quarter	1.14	0.893**	0.778***	0.926
	A quarter to half	1.062	0.869**	0.705***	0.792***
	More than half of your workforce	1.186	0.771***	0.590***	0.84
Have employees who regularly work from home		1.262***	1.194***	1.183***	1.361***
Perform regular risk assessment		1.197**	1.167***	1.22***	1.152*
Is a public company		1.115	0.93	0.926	1.037
Company arranges regular medical examinations		1.662***	1.21***	1.162***	1.194**
Company was visited by the labour inspector in the past three years		1.408***	1.274***	1.433***	1.352***

Source: Authors' calculations on ESENER-3 data.
Note 1: Selected 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; (iv) Wearable devices, such as smart watches, data glasses or other (embedded) sensors.
Note 2: N = 25,596.
Note 3: * indicates a statistical significance of 0.1; ** indicates a statistical significance of 0.05; *** indicates a statistical significance of 0.01.
Note 4: Robust quasi-maximum likelihood robust standard error was applied to ensure robustness.
Note 5: There was no collinearity issues in the model (all coefficients had a Variance Inflation Factor below 10).

10 Annex IV – European Company Survey (ECS-2019) analysis

Similarly, to the ESENER-3 analysis, ECS-2019 is used to explore the implementation of technologies throughout the EU-27 (2020) that could be linked to AIWM. This is done by exploring a question from the management survey PCWKMACH: For how many employees at this establishment is the pace of work determined by machines or computers? It bares mentioning that ECS-2019 also contains a question on worker monitoring (question code: ITPERFMONER) that is connected to worker management, but it will not be explored in the analysis. Besides, worker monitoring is already, to an extent, explored in ESENER-3. Table IV-1 provides the distribution of answers.

Table IV-1: Workplaces that use machines or computers to determine the pace of work of their employees (%; EU-27, 2019)

For how many employees is pace of work determined by machines or computers? (ECS-PCWKMACH)	Percentage of workplaces
None at all	8,844
Less than 20%	4,066
20% to 39%	2,327
40% to 59%	1,916
60% to 79%	1,520
80% to 99%	1,024
All	931
TOTAL	**11,784**

Source: Authors' elaboration on ECS-2019 data.

ECS-2019 will be analysed employing bivariate analysis and regression analysis. On the one hand, bivariate analysis will predominantly include descriptive statistics that can be used to understand the spread of technologies dictating the pace of work in the EU-27 (2020). Results for the bivariate analysis of ECS-2019 are provided in the following tables:

- Table IV-2: Workplaces that use machines or computers to determine the pace of work of their employees by country (%; EU-27, 2019)
- Table IV-3: Workplaces that use machines or computers to determine the pace of work of their employees by economic sector (NACE Rev. 2) (%; EU-27, 2019)
- Table IV-4: Weighted percentage of different type of workplaces in the EU-27 (2020) for which technologies determine the pace of work

On the other hand, regression analysis will be carried out employing OLS regression. OLS regression was selected for this analysis as the dependent variable in it – answers to the question for how many workers the pace of work is determined by a machine or computer – is ordinal in nature with seven unique values. More specifically, though ordinal data is not numeric, it can be treated as such when the sample size of the data is large enough and there are five or over of unique orders (Sullivan & Artino, 2013). For the results of the regression analysis, see Table IV-5: OLS regression results indicating how different factors affect the use of machines and computers to determine the pace of work.

Table IV-2: Workplaces that use machines or computers to determine the pace of work of their employees by country (%; EU-27, 2019)

Country	For how many employees is the pace of work determined by machines or computers?						
	None at all	Less than 20%	20% to 39%	40% to 59%	60% to 79%	80% to 99%	All
AT	53.9%	19.9%	9%	5.2%	4.7%	4.3%	3.1%
BE	59.5%	14.8%	6.5%	6.4%	5.9%	2.4%	4.5%
BG	30.2%	20%	15.3%	9.5%	9.9%	7.7%	7.3%
CY	39.1%	15.3%	15.5%	8.2%	3.3%	8.7%	9.9%
CZ	42.4%	19.6%	11.2%	10.3%	5.3%	5%	6.2%
DE	69.2%	14.7%	6%	3.9%	2.8%	2.1%	1.3%
DK	58.5%	15.9%	6.9%	6.1%	3.6%	4.2%	4.9%
EE	31.5%	16.6%	12.4%	10.5%	10.3%	8.1%	10.6%
EL	26.1%	13.8%	13.9%	12.9%	10.5%	8.1%	14.7%
ES	60.7%	16.4%	7.3%	5.5%	4%	3.7%	2.5%

Country	For how many employees is the pace of work determined by machines or computers?						
	None at all	Less than 20%	20% to 39%	40% to 59%	60% to 79%	80% to 99%	All
FI	47.4%	21.8%	9.5%	6.1%	6.8%	3.7%	4.7%
FR	67.6%	11.3%	5.7%	4.4%	4%	2.8%	4.2%
HR	24%	19.4%	17.4%	11.2%	10%	7.9%	10.2%
HU	40.8%	15.3%	12.1%	10.6%	8%	7.3%	6%
IE	46.7%	14.5%	9.4%	8.3%	6.3%	9%	5.7%
IT	37.1%	17.8%	14.6%	11.1%	8.4%	5%	5.9%
LT	43.8%	23.1%	10.6%	6.1%	5.2%	4.6%	6.6%
LU	65.1%	13.5%	7.7%	4.6%	1.5%	3%	4.6%
LV	26%	26.6%	16.7%	8.7%	8.2%	6.3%	7.5%
MT	36.6%	16.1%	9.5%	13.9%	6.5%	10.3%	7.1%
NL	51.2%	15.7%	9.9%	8.5%	5.3%	4.5%	5%
PL	52.8%	16.6%	10.8%	6.9%	6.4%	2.9%	3.5%
PT	50.1%	16.1%	9.3%	10.4%	6.6%	3.4%	4.1%
RO	29.2%	22%	16.4%	11.3%	7.9%	5.8%	7.3%
SE	58.6%	18.9%	6.3%	5.2%	3.7%	3.4%	3.8%
SI	39%	20.1%	12.7%	10.1%	8.9%	3.9%	5.2%
SK	64%	10.3%	9.8%	6.5%	3.1%	1.9%	4.4%

Source: Authors' elaboration on ECS-2019 data.
Note: Data was weighted using the *5_wgt_final* variables from ECS-2019, which is recommended to be used to account for sampling and other errors (Cedefop & Eurofound, 2019b).

Table IV-3: Workplaces that use machines or computers to determine the pace of work of their employees by economic sector (NACE Rev. 2) (%; EU-27, 2019)

Economic sector (NACE Rev. 2)	For how many employees is the pace of work determined by machines or computers?						
	None at all	Less than 20%	20% to 39%	40% to 59%	60% to 79%	80% to 99%	All
B	33.3%	29.6%	6.4%	9.2%	9.8%	1.4%	10.3%
C	29.9%	18%	16.1%	13.6%	12.9%	6.4%	3.1%
D	52.4%	17.8%	8.1%	7.2%	8.2%	2.2%	4.1%
E	49.5%	19.8%	15.1%	8%	3.3%	2.7%	1.7%
F	62.1%	19%	9.5%	4.7%	2%	1.2%	1.5%
G	58.8%	15.3%	8.7%	7.2%	4%	2.6%	3.4%
H	52.8%	15.4%	8%	5.1%	5.3%	8.2%	5.2%
I	65%	19.2%	8%	4.3%	0.8%	1.1%	1.6%
J	61.8%	12.1%	3.6%	4.1%	4.7%	5.5%	8.2%
K	66.7%	7.8%	4.2%	3%	4.3%	3.9%	10.1%
L	70%	7.5%	4.9%	3.2%	3.5%	5.2%	5.7%
M	63.3%	10.3%	4.9%	4.4%	2.6%	5%	9.5%
N	64.2%	17.3%	3.7%	4.3%	3%	3.8%	3.7%
R	65.5%	15.2%	8.6%	3.2%	3.4%	2.8%	1.3%
S	56.1%	16.4%	7.8%	5.1%	4.6%	3.2%	6.8%

Source: Authors' elaboration on ECS-2019 data.

Note: Data was weighted using the 5_wgt_final variables from ECS-2019, which is recommended to be used to account for sampling and other errors (Cedefop & Eurofound, 2019b).

Note: NACE Rev. 2 sectors: B – Mining and Quarrying; C – Manufacturing; D – Electricity, Gas, Steam and Air Conditioning Supply; E – Water Supply; Sewerage, Waste Management and Remediation Activities; F – Construction; G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H – Transportation and Storage; I – Accommodation and Food Service Activities; J – Information and Communication; K – Financial and Insurance Activities; L – Real Estate Activities; M – Professional, Scientific and Technical Activities; N – Administrative and Support Service Activities; R – Arts, Entertainment and Recreation; S – Other Service Activities.

Table IV-4: Workplaces that use machines or computers to determine the pace of work of their employees by specific characteristics of the workplace (%; EU-27, 2019)

Variables	For how many employees is the pace of work determined by machines or computers?					
	None at all	Less than 20%	20% to 39%	40% to 59%	60% to 79%	80% to 99%	All
Number of workers:							
10 to 49 people	56.8%	14.4%	9.1%	6.5%	5%	3.6%	4.7%
50 to 249 people	44.2%	23.2%	9.7%	8.7%	6.6%	5.1%	2.5%
250+ people	32.6%	28.1%	10.6%	12.7%	10.1%	4.3%	1.6%
Company age:							
10 years or less	51.1%	16.7%	9.8%	6.5%	4.7%	4.9%	6.3%
11 to 20 years	52.8%	17.3%	9.7%	5.8%	5.2%	3.6%	5.6%
21 to 30 years	56.6%	14%	9%	6.5%	5.4%	4%	4.4%
More than 30 years	54.4%	16.5%	9%	8.2%	5.7%	3.6%	2.7%
Organisation has a suggestion scheme:							
Yes	51.7%	17.2%	9.3%	7.1%	6.2%	4.1%	4.3%
No	55.8%	15.4%	9.2%	6.9%	4.8%	3.7%	4.3%

Source: Authors' elaboration on ECS-2019 data.
Note: Data was weighted using the *5_wgt_final* variables from ECS-2019, which is recommended to be used to account for sampling and other errors (Cedefop & Eurofound, 2019b).

Table IV-5: OLS regression results indicating how different factors affect the use of machines and computers to determine the pace of work

	Variables	Coefficient	EXP(Coeff.)	Std. error	z	p-value	
Constant		1.575	4.829	0.151	10.400	<0.001	***
Country codes (LU excluded)	**AT**	0.357	1.428	0.118	3.030	0.002	***
	BE	0.258	1.295	0.118	2.192	0.028	**
	BG	1.051	2.860	0.121	8.656	<0.001	***
	CY	1.133	3.104	0.227	4.987	<0.001	***
	CZ	0.621	1.860	0.121	5.134	<0.001	***
	DE	-0.122	0.885	0.117	-1.042	0.297	
	DK	0.376	1.456	0.118	3.175	0.002	***
	EE	1.278	3.591	0.141	9.070	<0.001	***
	EL	1.622	5.062	0.142	11.430	<0.001	***
	ES	0.072	1.075	0.113	0.641	0.522	
	FI	0.435	1.545	0.119	3.657	0.000	***
	FR	0.097	1.102	0.114	0.853	0.394	
	HR	1.311	3.711	0.133	9.836	0.000	***
	HU	0.850	2.341	0.121	7.010	0.000	***
	IE	0.761	2.139	0.154	4.923	0.000	***
	IT	0.862	2.367	0.116	7.439	0.000	***
	LT	0.592	1.808	0.132	4.489	0.000	***
	LV	1.096	2.991	0.134	8.180	0.000	***
	MT	1.278	3.588	0.195	6.552	0.000	***
	NL	0.558	1.748	0.117	4.763	0.000	***
	PL	0.395	1.485	0.119	3.317	0.001	***
	PT	0.398	1.488	0.120	3.306	0.001	***
	RO	0.989	2.688	0.125	7.913	0.000	***
	SE	0.114	1.121	0.116	0.978	0.328	
	SI	0.698	2.009	0.130	5.347	0.000	***
	SI	0.262	1.300	0.138	1.899	0.058	*
NACE Rev. 2 sectors[83] (E excluded while other sectors	**B**	0.598	1.819	0.220	2.715	0.007	*
	C	0.959	2.608	0.081	11.830	0.000	***
	D	0.324	1.383	0.146	2.221	0.026	**

[83] NACE Rev. 2 sectors: B – Mining and Quarrying; C – Manufacturing; D – Electricity, Gas, Steam and Air Conditioning Supply; E – Water Supply; Sewerage, Waste Management and Remediation Activities; F – Construction; G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles; H – Transportation and Storage; I – Accommodation and Food Service Activities; J – Information and Communication; K – Financial and Insurance Activities; L – Real Estate Activities; M – Professional, Scientific and Technical Activities; N – Administrative and Support Service Activities; R – Arts, Entertainment and Recreation; S – Other Service Activities.

	Variables	Coefficient	EXP(Coeff.)	Std. error	z	p-value	
were not present in ECS-2019, such as A, O, P)	**F**	-0.145	0.865	0.084	-1.729	0.084	***
	G	0.051	1.052	0.083	0.618	0.537	
	H	0.392	1.480	0.096	4.093	0.000	***
	I	-0.355	0.701	0.087	-4.092	0.000	
	J	0.399	1.491	0.109	3.665	0.000	**
	K	0.327	1.387	0.131	2.497	0.013	*
	L	-0.047	0.954	0.131	-0.361	0.718	***
	M	0.394	1.483	0.097	4.044	0.000	***
	N	0.275	1.316	0.107	2.559	0.011	***
	R	-0.165	0.848	0.099	-1.663	0.096	**
	S	0.205	1.227	0.088	2.336	0.020	**
Company size (250+ excluded)	**10 to 49 employees**	-0.250	0.778	0.042	-6.007	0.000	***
	50 to 249 employees	-0.110	0.896	0.042	-2.599	0.009	***
Company age (30+ excluded)	**10 years of less**	-0.016	0.984	0.042	-0.374	0.708	
	11 to 20 years	-0.058	0.944	0.034	-1.719	0.086	*
	21 to 30 years	-0.054	0.948	0.033	-1.646	0.100	*
Percentage of employees with an open-ended contract		0.019	1.019	0.009	2.133	0.033	**
Percentage of employees with a part-time contract		-0.050	0.951	0.010	-4.977	0.000	***
Percentage of employees who participated in a training session		0.017	1.018	0.008	2.195	0.028	**
Percentage of employees who participated in on-the-job training		0.044	1.045	0.008	5.331	0.000	***
Organisation has a suggestion scheme		0.122	1.130	0.026	4.637	0.000	***

Source: Authors' elaboration on ECS-2019 data.

Note 1: Variables in italics covering different percentages are variables that were on an ordinal scale that were transformed into numeric variables following Sullivan and Artino (2013).

Note 2: N = 19,609.

Note 3: * indicates a statistical significance of 0.1; ** indicates a statistical significance of 0.05; *** indicates a statistical significance of 0.01.

Note 4: Heteroscedasticity robust standard error was used to take into account the heteroscedasticity of residuals issue that was identified in the model.

Note 5: The manufacturing and wholesale and retail sectors had a collinearity issue (Variance Inflation Factor was around 10).

11 Annex V – Key words used for the literature review

Topic	Key words
RESEARCH (key concepts, definitions, types, categories of AIWM)	**Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ worker management**/workforce management/employee management/human resources management/business management/company management/workforce planning/operational management. **Artificial intelligence-based worker management/**artificial intelligence-enhanced human resources practices/algorithmic management/algorithm-based employment decisions/artificial intelligence decision-making/algorithmic decision-making/algorithmic decisions/big-data-driven decisions/management by algorithm/data analytics-based decisions. **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ worker**/workforce/employee/human resources/human capital/business/company/operational + **management + systems**/solutions/tools + types/forms/examples/categories/typology/techniques. **Worker-related data collection.** **Human resources automation;** human resources decision support system (HRDSS); digitalised management methods (DMSs); computerised decision-making systems. **Semi-automated/fully-automated +worker management (+practices).** **Human resources virtual assistance**/digital personal assistance. **People analytics**/human analytics/talent analytics/human resources analytics/workforce analytics; data analytics; predictive analytics; diagnostic analytics/prescriptive analytics **Gamification.** **Worker/employee+ performance+ rating/appraisal/evaluation+ systems.** **Video interviewing/facial recognition/voice recognition/automatic scheduling + software/tool + worker management.** **Worker/employee + surveillance/monitoring.**
POLICY (current and future national/company level/EU/sectoral/professional level policies/strategies/initiatives/programmes/ codes of practices/guidance relevant to the design, implementation and use of AIWM	**Artificial intelligence/**augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ governance.** **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ worker**/workforce + management **(+ occupational safety and health)** + **policies**/strategies/initiatives/programmes/codes of practices/guidance + EU/*member state*. **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ policies**/strategies/initiatives/programmes/codes of practices/guidance **+ EU/*member state*.** **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + **design/implementation/use** + **policies**/strategies/initiatives/programmes/codes of practices/guidance + **EU/*member state*.** **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + **policies**/strategies/initiatives/programmes/codes of practices/guidance/regulations+ **workplaces**/business/companies + **EU/*member state*.** **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ workplace sectoral** + **policies**/strategies/initiatives/programmes/codes of practices/guidance + ***member state*.** **New**/future **(+ worker management) + artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ policies**/strategies/initiatives/programmes/codes of practices/guidance. **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems (+ worker/workforce/employee+ management) + **policy recommendations/policy response.** **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + **worker management discussions.**

Topic	Key words
PRACTICE (purpose, drivers/hindrances, design, development, implementation, use & uptake, users)	**Advantages/benefits/positive impact/drivers + artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ workplace**/worker/employee/workforce//human resources/human capital/business/company/operational + **management.** **Roadblocks/barriers/obstacles**+ artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + **workplace**/worker/employee/workforce//human resources/human capital/business/company/operational + **management**; digital/artificial intelligence + **ethics**/transparency; **human intervention**/human interference/human involvement + algorithmic management; job-control; employee/worker/labour union + involvement decision-making; **data + governance**/management/collection/storing/use/access/ownership/privacy/mining; digital exhaust; digital footprint; digital whip. **Artificial intelligence/**augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + **use** + workplace/business/company. **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + **recruitment**/hiring/firing/candidate search; artificial intelligence resume screening tools; knowledge-based search engines; **staff rostering**/scheduling + algorithms; **worker sentiment analysis**; **assistants+ human resources management**; artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems (+ individual/team/organization) + **performance + monitoring**/evaluation; worker/workforce/employee + **monitoring/surveillance/tracking** + artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems; user activity monitoring (UAM) + artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems. **Building/constructing + human resources algorithm;** ergonomics + artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + worker management. **Future use + artificial intelligence**/augmented Intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ worker**/employee/workforce/workplace/human resources/human capital/business/company/operational + **management**; future + worker management/human resources management/artificial intelligence workplaces.
OSH (impact of AIWM on OSH, opportunities for OSH in AIWM, challenges for OSH by AIWM, OSH prevention)	**Algorithmic management/worker surveillance/worker monitoring+ impact/**effect**+ occupational health and safety/worker safety and health.** **Algorithmic management + job control/work pace/work intensity/performance pressure/invasion of privacy/job insecurity/income uncertainty. Artificial intelligence/**augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ workplace impact.** **Algorithmic management/worker surveillance/worker monitoring +workers/**employees**+ occupational health and safety/worker safety and health.** **Worker/**employee**+ wellbeing**/welfare+ algorithmic management/artificial intelligence management. **Artificial intelligence**/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **+ health risks;** occupational health and safety risks + artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems + worker/employee/workforce/human resources/human capital + management; worker health and safety challenges + artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems/algorithmic systems **Worker/**employee **+ physical**/**mental health/psychosocial + risks/challenges/concerns** + algorithmic/artificial intelligence/augmented intelligence/machine learning/robotics/intelligence systems + management. **Discrimination**/biased/unfair **+ algorithms**. **Work**/worker**+ stress/anxiety/cognitive overload/burnout + algorithmic management/worker surveillance/worker monitoring** **Musculoskeletal/cardiovascular+ disorders+ algorithmic management.** **Improve + occupational safety and health/worker safety and health** + algorithmic management/artificial intelligence worker management/**/worker surveillance/worker monitoring** **Occupational safety and health**/worker safety and health **+ risks+ prevention+ algorithmic management**/worker management through AI.

12 Annex VI – Questionnaire for written consultation with EU-OSHA's National Focal Points

Start of survey

We kindly invite you to participate in the consultation of the European Agency for Safety and Health at Work (EU-OSHA) National Focal Points. The survey aims to collect information on policies, strategies, initiatives, programmes, and codes of practice related to new forms of worker management using Artificial Intelligence (AI) and occupational safety and health (OSH). The results of this survey will help the EU-OSHA to better understand the potential consequences of AI-based worker management for workers' safety and health and identify the main challenges and opportunities for prevention, policy and practice, as well as to identify gaps and needs for policy and practice.

The results of the survey will be used in a report providing an overview of research, policies and practices in relation to new forms of worker management through AI-based systems and OSH. The study is being implemented by "Visionary Analytics" on behalf of EU-OSHA.

The answers that you will provide will be linked to the organisation that you represent, but not to your personal details.

Please reply to this survey by 31 March 2021 at the very latest.

Should you have any questions on this survey, please contact EU-OSHA.

Data Privacy and Informed Consent Information (mandatory)

Personal data will be processed in line with Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data. Within the project, the following personal data will be collected: Full name, country, organisation, E-Mail address.

The data collected will only be processed by Visionary Analytics and EU-OSHA employees entrusted with the implementation of the project.

The data collected in digital form will be stored for a maximum of 10 years. EU-OSHA will continue to keep the data in the form of aggregated results. Only authorised persons have access to the data. Your personal data will not be published. A subsequent use or transfer to third parties will not be done.

The full information regarding data protection is provided in the privacy statement that can be found in the information box under the title 'Background documents' on the right of the survey.

Please select:

☐ I agree to my data being processed as outlined in the privacy statement

☐ I do not agree to my data being processed as outlined in the privacy statement

If you do not agree, you refrain from participating in this consultation.

Scope of the consultation

This consultation is aimed at collecting information on **worker management through AI-based systems and OSH available in your country at several levels (such as national, social partner, sectoral, professional or workplace levels).**

AI-based worker management refers to the various management systems and tools collecting large amounts of real-time, constant data about workers' behaviours from various sources to inform management and make automated or semi-automated decisions based on algorithms or more advanced forms of AI.

AI-based worker management allow to rationalise the organisation of work and production, increase employers' control over their workers and the workplace, incorporate rating systems or other metrics in performance evaluation, indirectly incentivis worker behaviours through the use of 'nudges' and penalties. improve worker performance and productivity, profile workers, improve human resource (HR) management, reduce the cost to employers of monitoring and surveillance (replacing human supervisors with “electronic supervisors”). AI-based worker management systems can be:

- **Diagnostic** - used to determine something about (potential) workers and/or the work itself (e.g., worker performance, engagement, wellbeing, qualifications, to measure Key Performance Indicators (KPI)).
- **Predictive** - used to project the future direction of worker management and the company organisation (e.g., what skills workers should develop further, what actions should be taken to improve the wellbeing of workers, whether the workers are likely to be leaving the company)
- **Prescriptive** - used to provide solutions for worker management issues (e.g., optimisation of workforce planning, knowledge/talent management, providing organisational design).

Examples of AI-based worker management include **people analytics** (to measure, report and understand employee performance, aspects of workforce planning, talent management and operational management) and **gamification** (application of game techniques, such as rules, (real-time) feedback systems, rewards and videogame-like user interfaces, into non-game spaces, allowing to increase workers’ motivation and productivity, especially used in development, motivation, training and recruitment of workers).

They can be implemented in a variety of sectors and jobs across the economy. Many forms of worker monitoring are encompassed in ICT such as systems that automatically monitor web, email, social media, and text activity, and therefore potentially in any jobs using PCs and mobile devices such as phones and tablets. Data about workers can also be collected through smart wearables or any embedded ICT-based sensory devices, both in and outside the workplace.

These new forms of workers management can also be used to monitor and improve worker health and safety, training methods and efficiency. However, this questionnaire aims to collect information on systems implemented for the primary purpose of managing workers. Monitoring systems primarily aimed at improving OSH monitoring and workers’ safety and health are the focus of a separate EU-OSHA project.

With regard to the above, we aim to collect information on **regulation, policies, strategies, initiatives, programmes and codes of practices or guidance that are implemented or are still under discussion, relevant to the design, development, implementation and use of new forms of worker management through AI-based systems and OSH** (also including issues of data protection, consultation and involvement of workers and their representatives, worker consent, data access and ownership, data use, decision-making process related to workers, how are fast-changing innovative forms of worker management addressed, etc. that may be relevant to workers’ safety and health).

The regulation, policies, strategies, initiatives, programmes and codes of practices or guidance include those at the **national, sectoral, professional or workplace levels**.

INTRODUCTORY QUESTIONS

Q1.1. Please indicate your country:

[drop down-list of EU and EFTA countries]

Q1.2. Please describe the current situation of AI-based worker management practices in your country. Are these practices common? In which working contexts are they more common (e.g. sector, type of organisation)? How (if) OSH-related issues are addressed when implementing these practices?

………

Q1.3. Is there or has there been any debate on the use AI-based worker management in workplaces in your country, and what aspects are debated? Does this debate include OSH aspects, and if yes, which ones? When did the debate start? Who are the actors involved in the debate? What are their respective positions regarding AI-based worker management? Have relevant policies/strategies/initiatives/programmes been introduced? When did their implementation start and at what level?

Please note that the answer to this question should provide a general overview of the situation in your country. You will find specific questions relating to specific regulations/policies/strategies/programmes/initiatives in the next sections of the questionnaire.

………

Q1.4. What impact, if any, has the COVID-19 pandemic had on the use of new forms of AI-based worker management across workplaces in your country? Has the COVID-19 pandemic in any way encouraged the discussions about the impact the new forms of worker management have on OSH? Has it had an impact on the development of regulation, policy, strategies, initiatives, programmes, codes of practices/guidance or social dialogue/collective bargaining in relation to the AI-based management of worker and OSH? If yes, please briefly describe how, including the outcomes of these discussions and the actors involved.

……

Section I: Questions on regulations, policies and strategies

Current and recent

This group of questions is related to the regulations, policies and/or strategies implemented at national, sectoral, professional and workplace level related to worker management through AI-based systems and relevant to OSH. When providing your answers, please give as many details as possible.

Q2.1.1. Are there any regulations, policies and/or strategies implemented at the national, sectoral, professional and workplace level in your country that are related to worker management through AI-based systems and relevant for OSH (including aspects such as ethics, data protection, worker consent, consultation and involvement of workers and their representatives in the choice of systems or decision-making process, etc. that may be relevant to workers' safety and health)?

- Yes (→ Q2.1.4)
- No (→ Q2.1.2 → Q. 2.1.10)
- I do not know (→ Q2.1.3.→ Q. 2.1.10)

Q2.1.2. You have indicated that in your country there are no relevant regulations, policies and/or strategies. Please briefly explain why, in your opinion, AI-based worker management and its impact on OSH is not addressed by regulations, policies, strategies in your country (e.g. because the topic is novel, other aspects than OSH are discussed in relation to these systems, the AI-based worker management systems are not that widespread, etc.) (→ Q2.1.9.)

……
……

Q2.1.3. You have indicated that you are not aware of any relevant regulations, policies and/or strategies related to AI-based worker management and OSH in your country. Please briefly describe the main reasons for not being able to provide this information (e.g. there is a lack of understanding as to what AI-based worker management is, the topic is out of scope of your work, your organisation/institution does not collect such information, etc.) (→ Q2.1.9.)

……
……

Q2.1.4. Please list **regulations**, **policies** and/or **strategies** implemented at the **national, sectoral professional and workplace level in your country** which are relevant to the design, development, implementation and use of new forms of worker management through AI-based systems. Please indicate: name of the regulation/policy/strategy and level of implementation (i.e. national, sectoral, professional, workplace) and provide links to the official documentations of these regulations/policies/strategies (use relevant text boxes below):

Regulation/Policy/strategy #1 [name, level of implementation, link to documentation]

Regulation/Policy/strategy #2 [name, level of implementation, link to documentation]

Regulation/Policy/strategy #3 [name, level of implementation, link to documentation]

…

Q2.1.5. Please provide (1) a brief description of each identified regulation, policy and/or strategy, including its scope and objectives (2) how they affect worker management through AI-based systems, and specify which topics they cover.

The topics might be related but not limited to the following:

- **Data governance related topics** (e.g. type of data collected and method of data collection, data access and ownership, data protection, data use, worker consent, etc.).
- **Worker participation related topics** (e.g. consultation and involvement of workers and/or their representatives in the decision-making).
- **Topics related to the type of technology in the workplace or to the type of worker management** (e.g. AI technologies, information and communication technologies, people analytics, gamification).

Regulation/Policy/strategy #1 [description]

Regulation/Policy/strategy #2 [description]

Regulation/Policy/strategy #3[description]

…

Q2.1.6. Please describe how/if OSH issues are addressed in each of the regulations/policies/strategies identified. When describing, please specify in more detail the specific topics/aspects related to OSH that each identified regulation, policy and/or strategy cover. Please describe in as much detail as possible.

The **OSH-related topics** might be related, but not limited, to the following: workers safety issues, workers physical and/or mental health issues, occupational risks including ergonomics, psychosocial and organisational risk factors, OSH management system, consideration of these worker management practices in the workplace risk assessment, monitoring of the system's risks to workers, health surveillance, wellbeing of workers, OSH opportunities offered by the systems, etc.

Regulation/policy/strategy #1 [description]

Regulation/policy/strategy #2 [description]

Regulation/policy/strategy #3 [description]

……

Q2.1.7. Which actors initiated and/or participated in the development of each regulation, policy and/or strategy identified?

For each regulation/policy/strategy identified, please specify the name of the organisation of the main actors involved and their type (for example national government, local (region or city) government, public agencies, trade unions, works councils, employer or their organisations, bipartite bodies, tripartite bodies, think tanks, universities, etc.)

……

Q2.1.8. Which are the main target groups of the regulations, policies and/or strategies identified)?

For each regulation/policy/strategy identified, please include the name of the relevant regulation/policy/strategy and describe all the relevant target groups. For example, target groups can be but are not limited to: developers of AI worker management systems, workplaces in a specific sector, organisations of specific type and/or size, workers in a specific sector or type of job, specific groups of workers (age, gender, skills, work ability, migrant, etc.), specific place of work (mobile workers, teleworkers, 'traditional' workplace, etc.), other target groups. Please *specify relevant details as appropriate (e.g. 'name of the regulation/policy/strategy' targets teleworkers in IT and banking sectors, it only applies to larger organisations (250+ worker/employees)).*

……

Q2.1.9. Have the identified regulations/policies/strategies been evaluated? If yes, please briefly describe the outcome of the evaluation (e.g. impact of the regulation/policy/strategy, strengths and weaknesses, suggestions for improvements, etc.).

……

Under discussion

This question is related to regulation, policies and/or strategies at national, sectoral, professional and workplace level related to worker management through AI-based systems that are not yet adopted but are under discussion. Please refer both to current and recent relevant discussions on regulations/policies and/or strategies.

Q2.1.10. Are there any regulation, policies or strategies related to AI-based worker management which are not yet adopted but are currently under discussion in your country? If yes, please summarise the debate on each of these regulations/policies/strategies. For each policy/strategy, please:

- Provide an indicative name of the regulation/policy/strategy under discussion
- Indicate at which level it is intended to be implemented (i.e. national, sectoral, professional, workplace)
- Describe the contents of the regulation/policy/strategy under discussion, key actors involved and topics covered
- Indicate whether the debate includes issues related to OSH and provide relevant details/description
- Indicate the main target groups of the identified regulations, policies and/or strategies under discussion (for example, developers of AI worker management systems, workplaces in a specific sector, organisations of specific type and/or size, workers in a specific sector or type of job, specific groups of workers (age, gender, skills, work ability, migrant, etc.), specific place of work (mobile workers, teleworkers, 'traditional' workplace, etc.), other target groups)
- Provide links to official documentation, if applicable

Regulation/policy/strategy #1 [description……..]

Regulation/policy/strategy #2 [description……..]

Regulation/policy/strategy #3 [description……..]

…

Q2.1.12. Do you believe that the COVID-19 pandemic could affect the future development of policies and strategies that are relevant to the design, development, implementation and use of new forms of worker management through AI-based systems and OSH? If so, elaborate how:

………

Section II: Questions on initiatives and programmes

Current and recent

This group of questions is related to the initiatives and/or programmes related to worker management through AI-based systems and relevant to OSH. These initiatives/programmes might be implemented at the national, sectoral, professional or workplace level. When providing your answers, please give as many details as possible.

Q.2.2.1. Are there any initiatives and/or programmes implemented at the national, sectoral, professional and workplace level in your country, that are related to worker management through AI-based systems and relevant for OSH (including aspects such as ethics, data protection, worker consent, consultation and involvement of workers and their representatives in the choice of systems or decision-making process, etc. that may be relevant to workers' safety and health)?

- Yes (→ Q2.2.4)
- No (→ Q2.2.2 → Q. 2.2.10)
- I do not know (→ Q2.2.3→ Q. 2.2.10)

Q2.2.2. You have indicated that in your country there are no relevant initiatives and/or programmes. Please briefly explain why, in your opinion, AI-based worker management and its impact on OSH is not addressed by initiatives and/or programmes in your country (e.g. because the topic is novel, other aspects than OSH-related aspects are discussed in relation to these systems, the AI-based worker management systems are not that widespread, etc.) (→ Q2.2.10.)

………
………

Q2.2.3. You have indicated that you are not aware of any relevant initiatives and/or programmes related to AI-based worker management and OSH in your country. Please briefly describe the main reasons for not being able to provide this information (e.g. there is a lack of understanding as to what AI-based worker management is, the topic is out of scope of your work, your organisation/institution does not collect such information, etc.) (→ Q2.2.10.)

……
……

Q2.2.4. Please list **initiatives** and/or **programmes** implemented at the **national, sectoral, professional and workplace level in your country** that are relevant to the design, development, implementation, and use of new forms of worker management through AI-based. Please indicate: name of the initiative/programme and level of implementation (i.e. national, sectoral, professional, workplace) and provide links to the official documentations of these initiatives/programmes (use relevant text boxes below):

Initiative/programme #1 [name, level of implementation, link to documentation]

Initiative/programme #2 [name, level of implementation, link to documentation]

Initiative/programme #3 [name, level of implementation, link to documentation]

…

Q2.2.5. Please provide (1) a brief description of each identified initiative and/or programme, including its scope and objectives (2) how they affect worker management through AI-based systems, and specify and specify which topics they cover.

The topics might be related but not limited to the following:

- **Data governance related topics** (e.g. type of data collected and method of data collection, data access and ownership, data protection, data use, worker consent, etc.).
- **Worker participation related topics** (e.g. consultation and involvement of workers and/or their representatives in the decision-making).
- **Topics related to the type of technology in the workplace or to the type of worker management** (e.g. AI technologies, information and communication technologies, people analytics, gamification).

Initiative/programme #1 [description]

Initiative/programme #2 [description]

Initiative/programme #3 [description]

…

Q2.2.6. Please describe how/if OSH issues are addressed in each of the initiatives/programmes identified. When describing, please specify in more detail the specific topics/aspects related to OSH that each identified initiative/programme cover. Please describe in as much detail as possible.

The **OSH-related topics** might be related but not limited to the following: workers safety issues, workers physical and/or mental health issues, occupational risks including ergonomics, psychosocial and organisational risk factors, OSH management system, consideration of these worker management practices in the workplace risk assessment, monitoring of the system's risks to workers, health surveillance, wellbeing of workers, OSH opportunities offered by the systems, etc.

Initiative/programme #1 [description]

Initiative/programme #2 [description]

Initiative/programme #3 [description]

…

Q2.2.7. Which actors initiated and/or participated in the development of each initiative and/or programme identified?

For each initiative/programme identified, please specify the name of the organisation of the main actors involved and their type (for example national government, local (region or city) government, public agencies, trade unions, works councils, employer or their organisations, bipartite bodies, tripartite bodies, think tanks, universities, etc.)

……

Q2.2.8. Which are the main target groups of the identified initiatives and/or programmes)?

For each initiative/programme identified, please include the name of the relevant initiative/programme and describe all the relevant target groups. For example, target groups can be but are not limited to: developers of AI worker management systems, workplaces in a specific sector, organisations of specific type and/or size, workers in a specific sector or type of job, specific groups of workers (age, gender, skills, work ability, migrant, etc.), specific place of work (mobile workers, teleworkers, 'traditional' workplace, etc.), other target groups. Please specify relevant details as appropriate (e.g. 'name of the initiative/programme' targets teleworkers in IT and banking sectors, it only applies to larger organisations (250+ worker/employees)).

………

Q2.2.9. Have the identified initiatives and/or programmes been evaluated? If yes, please briefly describe the outcome of the evaluation (e.g. impact of the initiative/programme, strengths and weaknesses, suggestions for improvements, etc.).

………

Under discussion

This question is related to initiatives and/or programmes related to worker management through AI-based systems that are not yet adopted but are under discussion. Please refer both to current and recent relevant discussions on initiatives and/or programmes.

Q2.2.10. Are there any initiatives and/or programmes related to AI-based worker management which are not yet adopted but are currently under discussion in your country? If yes, please summarise the debate on each of these initiatives/programmes. For every initiative/programme, please:

- Provide an indicative name of the initiative/programme under discussion
- Indicate at which level it is intended to be implemented (i.e. national, sectoral, professional, workplace)
- Describe the contents of the initiative/programme under discussion, key actors involved and topics covered
- Indicate whether the debate includes issues related to OSH and provide relevant details/description
- Indicate the main target groups of the identified initiatives/programmes under discussion (for example, developers of AI worker management systems, workplaces in a specific sector, organisations of specific type and/or size, workers in a specific sector or type of job, specific groups of workers (age, gender, skills, work ability, migrant, etc.), specific place of work (mobile workers, teleworkers, 'traditional' workplace, etc.), other target groups).
- Provide links to official documentation, if applicable

Initiative/programme #1 [description……..]

Initiative/programme #2 [description……..]

Initiative/programme #3 [description……..]

…

Q2.2.11. Do you believe that the COVID-19 epidemic could affect the future development of initiatives and programmes that are relevant to the design, development, implementation and use of new forms of worker management through AI-based systems and OSH? If so, then elaborate how:

………

Section III: Codes of practices and guidelines

Current and recent

This group of questions is related to the codes of practices and guidelines related to worker management through AI-based systems and relevant to OSH. These codes of practices/guidelines might be implemented at the national, sectoral, professional or workplace level. When providing your answers, please give as many details as possible

Q2.3.1. Are there any codes of practices and/or guidelines at the national, sectoral, professional and workplace level in your country, that are related to worker management through AI-based systems and relevant for OSH (including aspects such as ethics, data protection, worker consent, consultation and involvement of workers and their representatives in the choice of systems or decision-making process, etc. that may be relevant to workers' safety and health)?

- Yes (→ Q2.3.4)
- No (→ Q2.3.2 → Q. 2.3.9.)
- I do not know (→ Q2.3.3.→ Q. 2.3.9.)

Q2.3.2. You have indicated that in your country there are no relevant codes of practices and/or guidelines. Please briefly explain why, in your opinion, AI-based worker management and its impact on OSH is not addressed by codes of practices and/or guidelines in your country (e.g. because the topic is novel, other aspects than OSH related aspects are discussed in relation to these systems, the AI-based worker management systems are not that widespread, etc.) (→ Q2.3.9)

………
………

Q2.3.3. You have indicated that you are not aware of any relevant codes of practices and/or guidelines related to AI-based worker management and OSH in your country. Please briefly describe main reasons for not being able to provide this information (e.g. there is a lack of understanding as to what AI-based worker management is, the topic is out of scope of your work, your organization/institution does not collect such information, etc.) (→ Q2.3.9.)

………
………

Q2.3.4. Please list **codes of practices** and/or **guidelines** implemented at the **national, sectoral, professional and workplace level in your country** that are relevant to the design, development, implementation, and use of new forms of worker management through AI-based systems. Please indicate: name of the code of practice/guideline and level of implementation (i.e. national, sectoral, professional, workplace) and provide links to the official documentations of these codes of practices/guidelines (use relevant text boxes below):

Code of practice/guidelines #1 [name, level of implementation, link to documentation]

Code of practice/guidelines #2 [name, level of implementation, link to documentation]

Code of practice/guidelines #3 [name, level of implementation, link to documentation]

…

Q2.3.5. Please provide (1) a brief description of each identified code of practice and/or guidelines, including its scope and objectives, (2) how they affect worker management through AI-based systems, and specify which topics they cover.

The topics might be related but not limited to the following:

- **Data governance related topics** (e.g. type of data collected and method of data collection, data access and ownership, data protection, data use, worker consent, etc.).
- **Worker participation related topics** (e.g. consultation and involvement of workers and/or their representatives in the decision-making).
- **Topics related to the type of technology in the workplace or to the type of worker management** (e.g. AI technologies, information and communication technologies, people analytics, gamification).

Code of practice/guidelines #1 [description]

Code of practice/guidelines #2 [description]

Code of practice/guidelines #3 [description]

…

Q2.3.6. Please describe how/if OSH issues are addressed in each code of practice and/or guidelines identified. When describing, please specify in more detail the specific topics/aspects related to OSH that each identified code of practice and/or guidelines cover. Please describe in as much detail as possible.

The **OSH-related topics** might be related but not limited to the following: workers safety issues, workers physical and/or mental health issues, occupational risks including ergonomics, psychosocial and organisational risk factors, OSH management system, consideration of these worker management practices in the workplace risk assessment, monitoring of the system's risks to workers, health surveillance, wellbeing of workers, OSH opportunities offered by the systems, etc.

Code of practice/guidelines #1 [description]

Code of practice/guidelines #2 [description]

Code of practice/guidelines #3 [description]

…

Q2.3.7. Which actors initiated and/or participated in the development of code of practice and/or guidelines identified?

For each code of practice/guidelines identified, please specify the name of the organisation of the main actors involved and their type (for example national government, local (region or city) government, public agencies, trade unions, works councils, employer or their organisations, bipartite bodies, tripartite bodies, think tanks, universities, etc.)

……

Q2.3.8. Who predominantly uses or has to follow the identified codes of practice and/or guidelines?

For each code of practice/guidelines identified, please include the name of the relevant code of practice/guidelines and describe all the relevant target groups. For example, target groups can be but are not limited to: developers of AI worker management systems, workplaces in a specific sector, organisations of specific type and/or size, workers in a specific sector or type of job, specific groups of workers (age, gender, skills, work ability, migrant, etc.), specific place of work (mobile workers, teleworkers, 'traditional' workplace, etc.), other target groups. Please *specify relevant details as appropriate (e.g. 'name of the code of practice/guidelines' is used by teleworkers in IT and banking sectors, it only applies to larger organisations (250+ worker/employees)).*

……

Under discussion

This group of questions is related to codes of practices and guidelines at national, sectoral, professional and workplace level related to worker management through AI-based systems and OSH which are not yet adopted but are under discussion. Please refer both to current and recent relevant discussions on codes of practices and guidelines.

Q2.3.9. Are there any codes of practice and/or guideline's related to AI-based worker management which are not yet adopted but are currently under discussion in your country? If yes, please summarise the debate on each of these codes of practice/guidelines. For every code of practice/guidelines, please:

- Provide an indicative name of the code of practice/guidelines under discussion
- Indicate at which level it is intended to be implemented (i.e. national, sectoral, professional, workplace)
- Describe the contents of the code of practice/guidelines under discussion, key actors involved and topics covered
- Indicate whether the debate includes issues related to OSH and provide relevant details/description
- Indicate the main target groups of the identified codes of practice/guidelines under discussion (for example, developers of AI worker management systems, workplaces in a specific sector, organisations of specific type and/or size, workers in a specific sector or type of job, specific groups of workers (age, gender, skills, work ability, migrant, etc.), specific place of work (mobile workers, teleworkers, 'traditional' workplace, etc.), other target groups
- Provide links to official documentation, if applicable

Code of practice/guidelines #1 [description……..]

Code of practice/guidelines #2 [description……..]

Code of practice/guidelines #3 [description……..]

…

Q2.3.10. In your opinion, could the COVID-19 epidemic affect the future development of practices and guidelines that are relevant to the design, development, implementation and use of new forms of worker management through AI-based systems and OSH? If so, then elaborate how:

………

Section IV: Social dialogue and collective bargaining

Current and recent

This group of questions is related to the systems of social dialogue and collective bargaining in your country and whether they address issues related to worker management through AI-based systems and relevant to OSH. They might be implemented at the national, workplace, sectoral or professional level.

Q2.4.1. Are any issues related to AI-based worker management addressed through social dialogue and/or collective bargaining (at national, sectoral or workplace level) in your country?

- Yes (→ Q2.4.4)
- No(→ Q2.4.2 → Q2.4.6)
- Do not know (→ Q2.4.3 → Q2.4.6)

Q2.4.2. You have indicated that in your country AI-based worker management is **not addressed** through social dialogue and/or collective bargaining. Please briefly explain what, in your opinion, are the reasons (e.g. because the topic is novel, other aspects than OSH related aspects are discussed in relation to these systems, the AI-based worker management systems are not that widespread, etc.) (→ Q2.4.6)
………

Q2.4.3. You have indicated that you are not aware whether AI-based worker management is addressed through social dialogue and/or collective bargaining in your country. Please briefly describe main reasons for not being able to provide this information (e.g. there is a lack of understanding as to what AI-based worker management is, the topic is out of scope of your work, your organization/institution does not collect such information, etc.) (→Q2.4.6)
………

Q2.4.4. Please summarise the following information regarding social dialogue and/or collective bargaining. When describing, please indicate whether you are referring to social dialogue or collective bargaining (incl. level of collective bargaining, i.e. national, sectoral, workplace level).

(1) *A brief description of which particular issues related to AI-based worker management are addressed through social dialogue and/or collective bargaining.*
The topics might be related but not limited to the following:
- ***Data governance related topics** (e.g. type of data collected and method of data collection, data access and ownership, data protection, data use, worker consent, etc.).*
- ***Worker participation related topics** (e.g. consultation and involvement of workers and/or their representatives in the decision-making).*
- ***Topics related to the type of technology in the workplace or to the type of worker management** (e.g. AI technologies, information and communication technologies, people analytics, gamification).*

(2) *A brief description of whether and which particular **issues related to OSH** are addressed and how. For example, workers safety issues, workers physical and/or mental health issues, occupational risks including ergonomics, psychosocial and organisational risk factors, OSH management system, consideration of these worker management practices in the workplace risk assessment, monitoring of the system's risks to workers, health surveillance, wellbeing of workers, OSH opportunities offered by the systems, etc.*

(3) *Any tangible **outputs**, i.e. social pacts or collective agreements, related to AI-based worker management and OSH reached and their content (i.e. how does it affect/cover AI-based worker*

management and OSH). In case there were no tangible outputs reached, please explain the reasons behind this.

*(4) Links to the relevant **official documentations** (please use the boxes below):*

Social dialogue [description]
Collective bargaining at national level [description]
Collective bargaining at sectoral level [description]
Collective bargaining at workplace level [description]

…

Q2.4.5. Have there been actors other than government, employers and trade unions involved in the social dialogue/collective bargaining (incl. tangible outcomes) in relation to addressing issued related to AI-based worker management and OSH? These actors can, for example, be sectoral or workplace level organisations. Please specify the names of these actors for each of the process (i.e. social dialogue/collective bargaining) or inputs (i.e. social pats/collective agreements) described.

……

Under discussion

This group of questions is related to the discussions on including the aspect of issues related to AI-based worker management into social dialogue and/or collective bargaining. Please refer both to current and recent relevant discussions.

Q2.4.6. Are there any current discussions on including issues related to AI-based worker management into social pacts and/or collective agreements at national, sectoral, professional and/or workplace level? If yes, please provide:
(1) A brief description of which particular issues related to AI-based worker management are addressed in social pact/collective agreement under discussion.
(2) A brief description of whether and which particular issues related to OSH are addressed in social pact/collective agreement under discussion and how.
(3) Names of actors other than government, employers and trade unions involved in the social dialogue/collective bargaining (incl. tangible outcomes) in relation to addressing issued related to AI-based worker management and OSH. These actors can be, for example, sectoral or workplace level organisations.
(4) Links to the relevant official documentations:

Social pact/collective agreement #1 [description]

Social pact/collective agreement #2 [description]

Social pact/collective agreement #3 [description]

…

Q2.4.7. In your opinion, could the COVID-19 epidemic affect the future development of social dialogue and collective bargaining by including issues related to the design, development, implementation and use of new forms of worker management through AI-based systems and OSH? If so, then elaborate how:

……

Section V: Uptake

This group of questions is related to the most common **AI-based worker management practices** that are currently implemented in workplaces in your country, the purpose of these practices, as well as their uptake and potential barriers.

Q3.1. Are there any AI-based worker management practices implemented in workplaces in your country?

- Yes (→ Q3.4.)
- No (→ Q3.2. → Q4.1)
- I do not know (→ Q3.3.→ Q4.1)

Q3.2. You have indicated that there are no AI-based worker management practices implemented in workplaces in your country. Please briefly explain why in your opinion, workplaces in your country do not use worker management systems based on AI. (→ Q4.1)

……

Q3.3. You have indicated that you are not aware of any AI-based worker management practices implemented in workplaces in your country. Please briefly explain why such information might be difficult to obtain (e.g. no central source of information about the implementation of such systems in workplaces in your country , workplaces do not provide/are not asked to provide such information, etc. (→ Q4.1)

……

Q3.4. Please list AI-based worker management practices and/or organisations which implement such practices in workplaces in your country.

Practice/organisation #1 [write-in]

Practice/organisation #2 [write-in]

Practice/organisation #3 [write-in]

…

Q3.5. What is the main purpose of the identified AI-based worker management practices? Are you aware about any discussions on the impact, challenges and opportunities to OSH related to these practices? Please provide description of each of the practices identified

Practice/organisation #1 [description]

Practice/organisation #2 [description]

Practice/organisation #3 [description]

…

Q3.6. How widespread are these practices?

For example, these practices are used in very few workplaces, or in several or majority of workplaces in your country, or only in in specific sectors or regions. Please specify the details and indicate specific sectors (if applicable).

……

Q3.7. Are there any cases that you would consider to be good examples of implementation of AI-based worker management practices (incl. how issues related to OSH are addressed) in your country? If yes, please provide: name of the case, name of the organisation, brief description of the case, contact person within the organisation and links to further information (if any):

……

Q3.8. To the best of your knowledge, what are the main barriers for (other) companies to implement these practices?

- There is no need as the existing, and simpler, practices already do the job
- The existing AI-based practices only fit very specific needs that not all companies have
- Lack of know-how on such tools or how to use them
- Lack of trust in AI-based systems
- Negative employees' perception and attitudes towards AI-based tools
- Potential negative physical health effects on workers
- Potential negative psychosocial health effects on workers
- Potential incidents and accidents in workplaces
- Lack of assessment on effects on workers' health and safety
- Too expensive
- Lack of national regulation
- Other, please specify:…

Q3.9. If you have additional insights regarding the identified AI-based worker management practices (e.g. contacts of individuals who manage them), please also write them down:

……

CONCLUDING QUESTIONS

Q4.1. Could you provide us with the names (contact details) of experts and other relevant actors on worker management through AI-based systems and/or OSH that we could potentially survey/interview?

Whenever possible, please indicate the following information about the expert/relevant actor: name, institutional/organisational affiliation, contact details (e-mail) and relevant experience or expertise (e.g. AI-based worker management, OSH, other).

……

Q4.2. If you are aware of any surveys and/or studies on topics such as OSH and AI-based worker managed systems, AI in uses in workplaces, and similar, please list them here (and, if possible, provide links):

……

Q4.3. Are you aware of any relevant practical tools for the assessment and/or prevention and control of OSH risks related to AI-based worker management? If yes, please list and briefly describe the content and topics of each tool below. If available, please provide links to documents describing these tools.

Tool #1 [name, description, relevant links]

Tool #2 [name, description, relevant links]

Tool #3 [name, description, relevant links]

…

Q4.4. This is the end of the questionnaire. If you have any other comments, remarks or information related to AI-based worker management and OSH in your country that you would like to add, please provide them below:

……

Q4.5. Can we contact you again if we have any additional questions? If yes, please provide your contact details below**:**

……

TE-RO-22-010-EN-N

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, 5th floor

48003 Bilbao, Spain

Tel. +34 944358400

Fax +34 944358401

E-mail: information@osha.europa.eu

Publications Office of the European Union