European Agency for Safety and Health at Work

Surveillance and Monitoring of Remote Workers: Implications for Occupational Safety and Heath

Report

European Agency for Safety and Health at Work

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Executive summary

The aim of this study is to analyse the OSH implications of surveillance and monitoring practices on remote workers. Although supervisors and forms of surveillance had always existed in workplaces, the advent of datafication of work processes and digitalisation of workplaces have spurred attention on how new technologies can affects workers' wellbeing and deteriorate working conditions.

The use of algorithms, artificial intelligence and digital tools is changing the way tasks are carried out, the relationships in workplaces and is modifying the chain of command and the role of middle-management. Digital technologies and algorithms may allocate tasks, control the workforce, measure productivity, and define working conditions. They may support and, in some cases, even replace management in the decision-making process as well as in monitoring activities. These empowered functionalities, however, many times come at the expense of workers' discretion and autonomy and are generally accompanied by intrusive technologies that may increase the psychosocial risks of workers and worsen their health outcomes, particularly of remote workers.

The use of data analytics and the automation process have transformed the workplace in data-driven spaces and gave rise to digital data-driven management models to assist management in the decision-making process and to improve efficiency. Although forms of scientific management are not a novelty, the scale and pervasiveness of new digital surveillance tools is such that large amount of data may be collected in real-time and surpass the work-related activities intruding eventually into workers' private sphere. Furthermore, most of these technologies may operate silently leaving workers unaware of being monitored or about the type and amount of data collected and for which purposes. This amplified use of surveillance and the constant feel of monitoring have also wide repercussions for job quality leading to reduced work autonomy, work intensification, increased level of stress and anxiety and reciprocal mistrust between workers and management. Remote workers, defined as workers who use digital technologies and work away from the employers 'premises, are at the forefront of the intensification of surveillance.

This study, using data from the EU-OSHA OSH Pulse survey, investigates how the adoption of different degrees of surveillance practices in the business model is associated with the presence of safety and health or psychosocial risks in the workplace. Secondly, it assesses the effects of preventive occupational safety and health (OSH) measures in mitigating the risks for workers under surveillance. Thirdly, it checks the impact of the embedded monitoring and surveillance practices in data-driven worker management on remote workers.

By using information on technology adoption and monitoring and surveillance practices, the study defines 'surveillance organisational models' those organisations that employ at least one digital technology to control workers' behaviour, performance, or physiology, and measures their impact on specific psychosocial risks and health outcomes, as well as analyses the mitigating effects of OSH preventive measures.

According to the findings, 78% of the total workers interviewed declared to be under some form of digital data-driven management and surveillance organisational models. That is, they report to either having digital technologies determining their speed of work, or monitoring and surveilling their work, or assigning them tasks or shifts, or evaluating their work or, finally, monitoring their vital signs.

Looking at the impact of surveillance organisational models on perceived psychosocial risks, workers reported that an increase of the use of surveillance digital tools corresponds to a higher perceived psychosocial risk.

When controlling for additional workers 'characteristics, the findings show that workers in clerical occupations and skilled workers are worse off than professionals and administrators while workers in sales and services are better off. Indeed, the adoption of technology may lead to reduced work autonomy and severe time pressure and work overload, which may be more severe for clerical occupations than professionals, while it reduces the risks of harassment and verbal abuse to which sales and services workers are more exposed. Furthermore, clerical and skilled workers may be more exposed to cognitive tasks' automation and to procedures that allow for a deeper monitoring of the work performed, both in terms of speed and steps to follow, generating higher psychosocial risks for them.

Looking at workplaces, working at the clients' premises increases work stress while, working from home reduces the psychosocial risks. This latter finding contrasts with previous research that finds a worsening of psychosocial risks for remote workers who work from home. A potential explanation for these contrasting findings could be that about half of the remote workers in the sample work from home and are professional, administrator or clerical workers. These workers may benefit from a greater autonomy and the possibility of work from home could, indeed, alleviate their work–life balance, reduce the commuting time and generally improve their life quality and mental health.

Looking at organisational and structural factors, being self-employed reduces the psychosocial risks associated with surveillance organisational models but only when OSH preventive measures are factored into the equation, which is a bit at odds, as normally OSH preventive measures do not directly target self-employed workers. Two issues may be considered here. First is that there are spill-over effects of the implementation of OSH-related awareness-raising activities that may produce indirect outcomes by increasing workers' awareness, particularly for the solo self-employed. Secondly, the majority of the self-employed are entrepreneurs who are most likely reporting about the OSH measures they apply in their workplace. When looking at companies' size, working for bigger firms gradually increases the psychosocial risks associated with surveillance organisational models, confirming that surveillance organisational models are mostly implemented by larger enterprises.

Finally, the introduction of OSH measures has a mitigating effect on psychosocial risks, except for measures involving counselling and psychological support. This result, however, may hint at a prejudice towards the use of counselling and therapy in the workplace more than a real inefficiency of the measure. Indeed, a majority of workers in 11 Member States 'strongly agree' or 'agree' that disclosing a mental health condition would have a negative impact on one's career.

When looking at the impact of surveillance on health outcomes the findings show that a surveillance organisational model increases the volume of health issues reported. In particular for unskilled workers who reported higher negative health outcomes. This may be explained by the fact that many unskilled workers generally perform physical work and tend to report more frequently bone, joint and muscle pains, that may aggravate with work intensification.

Working away from the employers' premises increases the average health reported outcomes almost for all workplaces except for the case of home-based workplaces. As found for psychosocial risks, remote workers who work from home report on average better health. When considering the effects of OSH preventive measures, only working from a public space and at the clients' premises report worse health outcomes, which is consistent with the fact that those are the two working environments where OSH preventive measures cannot be (entirely) implemented.

The results of this study clearly point towards an increasing adoption of digital data-driven worker management and surveillance technologies, for both remote and in-place workers. Similarly, the mitigating effects of OSH preventive measures have been confirmed by the empirical analysis. The use of algorithmic management and surveillance technologies at work affects workers' privacy and data rights, may hamper their freedom of association and worsen their working conditions as well as affect their mental and physical health. Intrusive and non-transparent surveillance practices could be addressed specifically within the regulatory framework on algorithmic management at work, currently in the policy debate at EU level and in some EU member states.

1. Introduction

Surveillance in the workplace is a long-standing practice. The first concerns about the computerisation of the workplace and electronic surveillance date back to the end of the 1980s, when Shosana Zuboff first introduced the term 'information panopticon' (Zuboff, 1988). In her remarkable study on the impact of technology in the workplace, she shows how management control is freed from the constraints of time and space and can operate unilateral surveillance by using electronic systems, anticipating many of the shifts in work process and power dynamics that affect today's job quality and can represent a concern for occupational safety and health (OSH).

The advent of the Internet and the technological progress of the last decades made digital surveillance even more efficient and intrusive, and the COVID-19 pandemic hastened a shift that was already underway. With millions of workers forced to work at home, businesses increased their digitalisation

efforts to keep tabs on workers' activity. The global demand for productivity and surveillance software has increased by over 54% since the beginning of the pandemic,[1] providing a vast array of tools that allow to constantly monitor and track remote workers. This is enabled by using GPS technology, by recording webcams and capturing screenshots, or by keeping logs of keystrokes and mouse movements, and, finally, reporting data analytics to managers and supervisors. The market for employee surveillance software was valued at US$1.12 billion in 2021 and it's expected to double its value by 2030, with Europe being the expected second largest market after North America.[2]

Before the pandemic hit, only 15% of European workers had **ever** teleworked whilst those regularly using flexible work arrangements were just above 5% of the employed in the European Union (EU).[3] In 2021, the share of people usually working from home almost trebled and reached 13.5%.[4] These figures refer mostly to dependent workers, and in most of the cases the concept of teleworking and working from home are used as equivalents. Data from the OSH Pulse survey of the European Agency for Safety and Health at Work (EU-OSHA), collected in spring 2022, show that almost 30% of employed in the EU-27 worked away from either the employer's or the client's premises, out of whom slightly above 16% worked from home. This figure includes also self-employed persons, who report usually higher shares of work from home. In 2019, already 19.4% of self-employed declared to be usually working from home.[5] Digging more into the characteristics of remote work, several studies point out that remote work arrangements are more common among high-skilled white collars and in knowledge-intensive and professional sectors (EU-OSHA, 2018; Eurofound, 2020b; Milasi et al., 2020). However, technology is not neutral and specific risks for workers' rights and health and safety are posed by its use.

The impact of digital surveillance in the workplace crosses several fields, from changes in the work organisation and the type of task performed to the employment status of workers, their job quality and wellbeing (Moore, 2020; Ball, 2021; Eurofound, 2022a; Aloisi and De Stefano, 2022a). While surveillance practices have always been there, the scale and pervasiveness they reach these days require an additional effort to fully understand the context in which they operate. The new digital surveillance at work is no longer a by-product of the business model, but it becomes a key profitable element of it (Zuboff, 2019). The economic orientation of digital surveillance is often overlooked in the context of labour, resulting in a public debate that mostly concentrates on trying to amend the negative outcomes of its use and marginally discuss its causes and legitimacy.

The short-term consequences of increased digital surveillance are already visible. Changes in work organisation and power dynamics have direct effects on the health and safety of workers, and remote workers are bearing the brunt of this transformation. Surveillance tools operate through recommending courses of actions, assigning ratings, penalties and incentives, and contributing to the 'gamification' of work influencing workers' behaviour (Mateescu and Nguyen, 2019; Casilli, 2019; Wood, 2021; Baiocco et al., 2022). The pervasiveness of such new technologies is such that the amount of data collected and stored may easily extend beyond work-related activities, intruding into the private life of workers and raising multiple privacy and ethical concerns (Adams-Prassl, 2020; Ajunwa, 2020; Moore, 2020; Aloisi and De Stefano, 2022b). Remote workers report higher level of anxiety and stress mainly associated with 'anticipatory surveillance' and eyestrain and musculoskeletal disorders (MSDs) due to intense use of information and communication technology (ICT) tools (Samek Lodovici et al., 2021).

This study is carried out on behalf of EU-OSHA and provides a framework of the OSH implications of surveillance practices on remote workers, analysing how the change in the organisational models affects workers' wellbeing using information from the EU-OSHA OSH Pulse survey. The aim is to inform policymakers and provide them with evidence-based policy suggestions to address the risks arising from surveillance and monitoring practices. The remainder of the report is organised as follows. Section 2 briefly presents the conceptual framework upon which the empirical analysis is built. Section 3 focuses on the impact of surveillance on remote workers. Section 4 describes the EU-OSHA OSH Pulse survey

[1] See: https://www.top10vpn.com/research/covid-employee-surveillance/
[2] See: https://www.sphericalinsights.com/reports/employee-monitoring-software-market
[3] See: jrc120945_policy_brief_-_covid_and_telework_final.pdf (europa.eu)
[4] See: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20221108-1
[5] See: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20200424-1#:%7E:text=In%202019%2C%205.4%25%20of%20employed,2009%20to%209.0%25%20in%202019

and presents the findings from the empirical analysis. Section 5 concludes and suggests policy implications.

2. The conceptual framework

Forms of control of workers have always existed and are part of the legitimate aspects of management and limited by labour legislation. Technological progress, however, have made more difficult to clearly draw a line between legitimate activities of monitoring and supervision and forms of surveillance that may be more intrusive and less objectively needed to verify the appropriate conduct of workers.

During and in the aftermath of the COVID-19 pandemic, physical distancing imposed by public health measures has prompted a big rush towards the adoption of new instruments for and new ways of organising the digital space, including the workspace. Telework, remote work, hybrid work and *bossware*[6] are just a few examples of new work terms that became popular amid the pandemic. The unprecedented circumstances that forced people worldwide to stay at home and work remotely have profoundly changed the common understanding of 'working day', redefining the space and time of work, as well as its organisation and the power dynamics involved.

Whilst the use of automated or semi-automated robots and machinery is not a novelty in industry and manufacturing, nor data analytics applied to work processes — the latter is at the core of Taylorism and scientific management — the changes introduced by digital technologies, including algorithmic technologies, data processing systems and artificial intelligence (AI), have modified radically and unilaterally the power of control and management exerted by employers with potential profound consequences on work organisation, working conditions, OSH and workers' power. In particular, the role of supervisors and managers, traditionally based on direct observation as well as on open and direct communication with employees, evolved in more aseptic forms of digital monitoring where the managers collect data and control indicators. Eventually the latter may give rise to forms of invasive surveillance, where more information than needed to evaluate work performance are collected and its use is not transparent for workers.

The capacity of data storage and data analytics of today's technologies is such that business operations and decisions are informed in nearly real time based on the continuous collection and analysis of data about workers and the workplace. A new organisational model built on data has emerged. Such a model entails also an entire new organisation of work and new worker management models. These systems are used to plan and organise workloads and the workforce, make predictions or decisions about workers, monitor and influence workers' behaviours, workers' surveillance, direct and control tasks, train or assist workers in their job, or automate tasks entirely (EU-OSHA, 2022b). In other words, algorithmic systems are transforming the workplace in data-driven workplaces where data (collection, storage and analytics) are used to assist, augment or automate work, and algorithms are supporting or replacing managerial decisions.

Such a new way of organising work and managing the workforce relies deeply on forms of control and surveillance of workers' activity inside and outside the work premises, as well as on the predictive analytics run by algorithms. If, on the one hand, technology is used to best predict and address potential risks for workers, sudden demand increase and productivity spikes may be an asset for both firms and workers and generate an improvement in terms of efficiency, and quality and safety of work, on the other hand the pervasiveness of this technology has implications that may put at risk workers' rights and health and safety.

2.1 Data-driven worker management model

Data-driven worker management models to assist management in the decision-making process are discussed already by Zuboff in 1988. Similarly, some specific applications of ICT have been used to coordinate and manage work processes already in the business process outsourcing (BPO) and call centres in the 1990s, which were defined as *algocratic governance systems* (Aneesh, 2009). Brynjolfsson and McElheran (2016) found that use of data-driven decision-making in United States

[6] See: https://www.eff.org/deeplinks/2020/06/inside-invasive-secretive-bossware-tracking-workers

manufacturing nearly trebled between 2005 and 2010. However, the full potential of these new organisational models was not entirely developed until the widespread adoption of general purpose technologies with embedded surveillance capacity in smartphone, wearables and portable devices that allow to extend monitoring and control to almost every aspect of daily life, including work.

The two pillars of this new organisational model are digital surveillance and monitoring, and algorithmic management, where the latter is defined 'as the use of computer-programmed procedures for the coordination of labour input in an organisation' (Baiocco et al., 2022). Both pillars of algorithmic and data-driven worker management entail data collection on workers and the workplace to run. The intrusiveness of such organisational models and the enormous amount of information collected blur the boundaries between employers' monitoring prerogatives and surveillance activities and pose a challenge to the power balance in the worker–employer relationship (Colclough, 2021; Baiocco et al., 2022; Aloisi and De Stefano, 2022). The amplified use of surveillance and the constant feel of monitoring also have wide repercussions for job quality, leading to reduced work autonomy, work intensification, increased level of stress and anxiety, and reciprocal mistrust between workers and management with serious consequences for the wellbeing of workers (Eurofound, 2020a; EU-OSHA, 2022c). In addition, the lack of a legislative framework clearly defining the perimeters and the legitimacy of these forms of control increases the uncertainty related to the development of these new tools and types of work arrangements (Eurofound, 2020a).

First, a warning comes from **data collection** and the legitimate use of data. Employers today may collect a vast array of information derived directly from the use of digital tools or monitoring tools at work, administrative data, and data coming from third parties (social media, insurance and credit history, health data, etc.). Whilst the latent harms of massive data collection and profiling on people's privacy are publicly discussed by government and academics, and regulations to protect consumers or to mitigate the risk of political manipulation and social harm have been introduced or proposed, there is very little discussion about the risk associated with the exploitation of workers' data and it is mostly focused on the bias and discrimination that could arise from feeding these data into algorithms that rule over hiring processes, tasks allocation, promotion or dismissal, and so on (Adler-Bell and Miller, 2018).

The General Data Protection Regulation (GDPR) is the major reference in terms of individual data protection in the EU and, although it has been introduced with the aim of protecting individual freedom rights and applies only to personal data,[7] may provide some measure to exert control on workers' data and prevent informational abuse that may come from faulty algorithmic decisions. Chapter 3 of the GDPR introduces a series of rights of the data subjects that includes a right to notify data subjects (in this case workers) when personal data are collected, for what purposes and for how long, and if those data are processed by automated decision-making, including profiling activities, data subjects have a right to be informed about the 'logic involved' (Article 13 and Article 14). Furthermore, Article 22[8] specifically limits the possibility of being subject to solely automatic decisions that produce legal effects.

Although the GDPR may provide a valid legal basis to assure fundamental data rights to workers, in practice two elements limit the power and applicability of the GDPR in the working context. The first one is the imbalance of power. All the data subject rights reported above remain individual rights that cannot be transferred to a collective representative, which in practical terms reduces these information rights in the working context to paperwork. Secondly, many of these limitations do not apply when the data subject makes explicit their consent, or if the decision 'is necessary for entering into, or performance of, a contract between the data subject and a data controller' (Article 22 (2)). If it is commonly agreed that explicit consent cannot be considered valid in an employment relationship (Article 29, Working Party),[9] it is less obvious if consent will be considered legitimate in the fulfilment of the contractual enforcement within the execution of the working relationship (Fernández-Macías et al., 2023; Aloisi, 2022).

[7] '"Personal data" means any information relating to an identified or identifiable natural person ("data subject"); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person' (Article 4). See: https://gdpr-info.eu/art-4-gdpr/

[8] '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' (Article 22). See: https://gdpr-info.eu/art-22-gdpr/

[9] See: https://ec.europa.eu/newsroom/article29/items/623051

Recent anecdotal evidence, mostly from the United States, showed that workers' data are not only collected and used to regulate the individual employer–employee working relationship but are also used to control collective behaviours and actions, and generate value. Indeed data on workers' collective behaviours have been used to predict strikes[10] and to target workers at risk of unionising.[11] Furthermore, as much as consumers and people generate content and data on the Internet, workers generate valuable data during working activities, which value is entirely extracted and used by employers. The data surplus generated by workers is neither redistributed nor used to increase workers' knowledge about the work processes — most of the time workers are unaware about the information collected and the way it is used — generating what Zuboff (2018) defines as 'behavioural surplus' and contributing to the commodification of labour. In other words, data extraction in the workplace indirectly affects working conditions by the means of algorithmic technologies, and directly reduces workers' surplus value and undermines their freedom of association. In this sense, a public debate on workers' data governance should be encouraged and measures to ensure a large and democratic participation of workers and their representatives adopted (Colclough, 2021; Baiocco et al., 2022).

Second, the digital tools used for **surveillance and monitoring** purposes are particularly intrusive and have the capacity to collect a constant flow of data and information about workers' location, actions and behaviours. Examples of monitoring technologies include badges and biometric scanners, GPS tracking locators and digital cameras, as well as software capable of detecting emotions or counting keystrokes and scrolling time. All these technologies are quite ubiquitous and present a real challenge when determining whether they are complying with the right of employers to monitor workers' activities or going beyond and becoming disproportionate or unnecessary, stimulating a vivid debate also on the effectiveness of the GDPR provisions (Aloisi, 2022). A second effect is that since these technologies go beyond the work premises and may be applied also to workers' own devices, the surveillance and control could be extended also to self-employed and non-standard workers, limiting their autonomy (Aloisi, 2022). The control exerted over these types of workers has generated controversies about the legitimate use of such tools and their employment status. Indeed, in parallel with the widespread adoption of digital devices and new technologies, there is a large consensus that the contractual relationships defining self-employment have evolved as well. The debate goes beyond the recognition of bogus self-employment and recognises the need to guarantee specific protections to vulnerable (or weak) self-employed workers (European Commission, 2021). These workers are experiencing new forms of technological dependence that on the one hand may grant greater flexibility in terms of space and time, but on the other may reduce their autonomy and discretionality in the execution of the task. A very clear example of this contradiction are platform workers, who are formally considered as self-employed workers but are *de facto* directed and monitored by the platform in the execution of their task in most of the circumstances (Pesole et al., 2018; De Stefano et al., 2021; Aloisi and De Stefano, 2022). Platform work could be considered as the precursor of the datafication of work and, as of today, these practices have been adopted as well by sectors in the traditional economy, in particular logistics and freelance activities (Delfanti, 2019: Wood, 2021; Baiocco et al., 2022). Indeed, the standardisation of the procedures implicit in the datafication of work, together with the possibility of remote and constant surveillance, has made it possible to resort in increasing quantities to contingent work exposing workers to greater risk of marginalisation, poor working conditions and lower degree of autonomy (Aloisi, 2022).

Finally, surveillance is perfectly integrated with **algorithmic management**. Certainly, the two concepts are intertwined, and algorithmic management assumes digital surveillance as a crucial component for its correct functioning, allowing the surveillance and management systems to seamlessly integrate. Indeed, the combined use of digital surveillance and algorithmic management comprises the key aspects of managerial prerogatives — organisation of work, monitoring and discipline — and defines the new managerial model of data-driven workplaces. Algorithmic technologies are used in several phases of the organisation of work, from hiring to tasks allocation, discipline and evaluation up to dismissal decisions. They determine the speed or pace of work, they collect data on task performance and workers' behaviours, and some may monitor the physical and mental state of workers by checking on heart rate and blood pressure and by detecting emotions and facial expressions. The major dangers associated with the use of algorithms principally deal with the risks of bias and discrimination, and the

[10] See: https://www.bloomberg.com/features/2015-walmart-union-surveillance/

[11] See: https://onezero.medium.com/companies-are-using-employee-survey-data-to-predict-and-squash-union-organizing-a7e28a8c2158

lack of transparency and accountability. In particular, 'algorithmic bosses' may be biased in terms of gender and race[12] during the hiring and promotion processes, or they may put too much pressure on workers' performance, generating stress, lowering the quality of their working conditions, and modifying their behaviours to the point of not enjoying acquired rights, such as rest breaks during the working day,[13] with considerable consequences for workers' health and safety (EU-OSHA, 2022c).

3. OSH implications for remote workers

A study commissioned by the European Parliament in 2019 on 'Health and safety in the workplace of the future' stated that the 'health and safety risks attributable to new technologies and patterns of work are currently under-researched'.[14] In particular, it called for more empirical evidence but also asked for consideration on the need to amend the current health and safety acquis in order to extend health and safety protections beyond employees to new forms of workers. This study contributes to this purpose by analysing the OSH implications of surveillance and monitoring practices on remote workers.

Whilst the COVID-19 restriction measures made it natural to think about remote work as work from home, there are actually several types of work arrangements that unfold away from the employment premises. The definitions of telework, remote work, hybrid work and home-based work may differ either for legislative purposes or statistical data collection. For example, the guideline put forth by the International Labour Organisation (ILO) for statistical purposes defines remote work as 'work [that] is fully or partly carried out on an alternative worksite other than the default place of work'[15] (ILO, 2020, p. 5), where the latter is established by the economic unit for which the workers provide labour services, in case of dependent workers, or by the facilities or premises controlled and used for the purposes of carrying out the work, in case of independent workers.[16] Default workplaces may include, therefore, employers' premises, workers' homes as well as clients' premises and public spaces according to the activity carried out. Telework is a particular type of remote work performed in an alternative workplace and by using a personal electronic device (smartphone, tablet, PC, etc.) (ILO, 2020, p. 6). For the purpose of this study, remote work is defined as 'any type of working arrangement involving the use of digital technologies to work from home or more generally away from the employer's premises or in a fixed location'.[17] This broader definition allows us to include also other workers who are facilitated by technologies and for whom the definition of the 'usual workplace' may not be easy. For example, this may be the case for platform workers or parcel delivery workers.

Most of the literature exploring the OSH implications of new technologies on remote work focuses on telework and platform work (Eurofound and ILO, 2017; EU-OSHA, 2021a; Bérastégui, 2021; Urzì and Curtarelli, 2022), and many of their findings could be extended to the more general definition of remote work adopted in this study. Generally, the OSH risk factors associated with remote work deal with the unsuitability of the workplace and the risk of accidents or injuries. An unfit workplace includes several aspects of the working environment such as lighting, temperature, potential environmental dangers or hazards, and presence of noises. Or, these could also be ergonomic issues due to the inadequate setting up of the workstation or the misuse of ICT equipment, leading mostly to eyestrain or MSDs (EU-OSHA, 2021a, Eurofound; 2020c, Samek Lodovici et al., 2021). Additionally, the literature on OSH risks in platform work particularly addresses issues related to food delivery services and passenger transport services (Bérastégui, 2021; EU-OSHA, 2022f), where the risk factors for platform workers are the same as those in the platform economy with the further negative outcomes associated with the implementation of tight forms of monitoring and surveillance and the adoption of algorithmic management practices. As explained by Bérastégui (2021), algorithmic management practices may result in work overload and intensification for platform workers, generating stress, anxiety and frustration that, coupled with the pressure of keeping a high rating, with isolation and the lack of social support, and with micromanagement through constant digital surveillance, may generate psychological responses, such

[12] See: https://scholarship.law.wm.edu/wmlr/vol58/iss3/4/
[13] See: https://www.theverge.com/2019/4/25/18516004/amazon-warehouse-fulfillment-centers-productivity-firing-terminations
[14] See: https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/638434/IPOL_BRI(2019)638434_EN.pdf
[15] See: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_747075.pdf
[16] Ibid.
[17] See: https://osha.europa.eu/en/themes/digitalisation-work

as burnout and exhaustion, as well as physiological ones such as back pain, headaches and cardiovascular diseases.

Lindholm et al. (2020) in their systematic literature review on future OSH developments pinpoint both technological advancements and changes in work management as responsible for an increase in psychosocial risks. They found that psychological stress and pressure will be exacerbated by the use of digital tools to monitor workers' behaviour and to determine the pace of work, and also by the constant need for learning and self-development to which workers will be exposed. Samek Lodovici et al. (2021) look at the impact on workers of telework and ICT-based mobile work (TICTM) and study the implications of TICTM on work flexibility and autonomy, work intensity and work–life balance, as well as on health and safety. They found that when remote work is associated with greater autonomy and flexibility, workers' outcomes are mostly positive. Indeed, they report increased level of productivity, better working time flexibility and improved work–life balance, reduction in commuting time and improvement in digital skills. Nevertheless, the literature shows that despite the high levels of autonomy granted to workers, this type of remote work arrangement can also lead to work intensification and virtual presenteeism. A phenomenon known as the **autonomy paradox**, which may lead to longer and irregular working hours, disrupts work–life balance and results in deterioration of workers' health (Eurofound and ILO, 2017; Eurofound, 2020c). The autonomy paradox may be triggered by changes in organisational management and communication with workers. In particular, work process monitoring, information overload and new social dynamic interactions permeated by constant connectivity may induce work intensification and work fragmentation with negative consequences for the workers' work–life balance and exposing them to greater vulnerability (Eurofound, 2020c). In addition, surveillance and monitoring technologies may create negative mental effects due to **anticipatory surveillance** generating a misuse of technological tools that leads to techno-stress and techno-addiction (Graveling, 2020; Samek Lodovici et al., 2021).

Another important aspect that should be taken into account is the correlation between psychosocial risk factors at work and the occurrence of MSDs (EU-OSHA, 2021b). Psychosocial risk factors at work can influence the occurrence of MSDs by triggering stress mechanisms or by increasing biomechanical exposure, and the effects are stronger when job strain situations are associated with poor social support and isolation (Roquelaure, 2018; EU-OSHA, 2021b). In other words, work organisation and management practices, by defining the conditions under which work is carried out, may generate a domino effect that involves both psychosocial risk factors and biomechanical exposure, increasing the risk of MSDs (EU-OSHA, 2021b). New technologies and data-driven worker management could influence biomechanical exposure in different directions. Indeed, the use of robots and the integration of automation may decrease the exposure to strenuous physical work, repetitive movements and awkward postures, as well as reduce the occurrence of incidents and injuries, particularly in high-risk sectors (EU-OSHA, 2021b, 2022d). Furthermore, digital monitoring in data-driven management models may improve OSH for example flagging workers working excessively long hours, or without breaks, or indicating when a worker is overloaded or emotionally stressed , or flaggingaggressive clients for employer immediate action. Nevertheless, the adoption of data-driven worker management seems to be mostly associated with increased time pressure and constant monitoring, very repetitive light work and lack of opportunities to take breaks, and increase in sedentary work (EU-OSHA, 2021b). Similarly, new organisational models based on data and surveillance reinforce the exposure of workers to psychosocial risk factors, such as increased work intensity, reduced work autonomy, high cognitive overload and emotional pressure, isolation and ethical concerns. The latter may induce a general feeling of lack of fairness and trust that may affect workers' confidence in the organisation and exacerbate their physical and mental wellbeing.

In this matter, the role played by institutions may be fundamental. In order to enforce a correct use of technologies at work, labour authorities could be granted access to monitoring data in order to verify law compliance, as well as trade unions to allow for collective bargaining on the adoption and implementation of digital technologies. In Italy, a preliminary attempt in this direction has been achieved through the introduction of the Legislative Decree104/2022 that transposes the EU Directive on Transparent and Predictable Working Conditions and grants data access not only to workers and their representatives, but also to labour inspectors. However, despite the revolutionary take proposed by the Italian law, and taken into account also the limitation given by the field of application of the original directive, the practical implementation of the law has been hampered by the knowledge gap of public

institutions and trade unions in data management and analytics and the lack of digital infrastructural support.

4. Evidence from the EU-OSHA OSH Pulse survey data

Using data from the EU-OSHA OSH Pulse survey, this section analyses the impact of the data-driven worker management model on health outcomes and psychosocial risks by using information about the type of technology implemented at the workplace and its purposes. The aim of the study is threefold. The first is to investigate how the adoption of different degrees of surveillance practices in the business model is associated with the presence of safety and health or psychosocial risks in the workplace. Secondly, it is to assess the effects of preventive OSH measures in alleviating the risks for workers under surveillance. Thirdly, it is to check the impact of the embedded monitoring and surveillance practices in data-driven worker management on remote workers.

OSH Pulse survey information about the place of work allows us to distinguish between employees working at the employers' premises and remote workers. In this analysis, the study distances itself from the ILO definition of remote work and the concepts of default workplace, as the objective is to capture the OSH implications of monitoring and surveillance technologies whether applied as a result in the change of the usual workplace (i.e. workers who start teleworking from home) or just implemented to control workers who traditionally were not under direct employers' surveillance given the nature of their job (i.e. drivers, parcel delivery workers, etc.). The empirical analysis carried out in the following section evaluates if data-driven worker management models produce different effects among in-place and remote workers.

Another aspect to consider is that digital technologies, including monitoring and surveillance ones, are adopted and produce different effects according to workers' occupations and industry. Clearly not all occupations will be equally affected by the introduction of technology, as some of the tasks require some cognitive abilities that technology is not yet able to replicate (Tolan et al., 2020) and therefore make those occupations more resilient to forms of automatic control and management. At the same time some industries may be more innovative, or on the contrary the presence of a relatively cheap unskilled workforce may hamper the implementation of costly technology and restructuring, generating differences across industries (Dosi, 1984; Sandrini, 2021).

4.1 Data description

The Flash Eurobarometer - OSH Pulse survey was commissioned by EU-OSHA in April 2022 to obtain information about the psychosocial risk factors and the mental and physical health issues faced by workers in the aftermath of the pandemic, and the importance of implementing OSH measures in the workplace. The survey collects information also about the use of digital technologies at work and the health and psychosocial risks related to digitalisation and forms of surveillance in the workplace. It also reports on OSH management, including measures to address stress and provide counselling or psychological support. Workers are asked directly which type of technology they use at work, and for which purposes the organisation introduced it. Using this information, it is possible to derive an organisational model indicator that proxies the data-driven worker management model described in section 2. The organisational model indicator provides an approximation of the degree of surveillance adopted in the workplace by combining both organisational and working procedural aspects. Its description follows in the next section.

The questionnaire also asks about the initiatives and measures put in place to address mental and physical health in the workplace, with a strong focus on how organisations deal with stress related to the use of new types of technology and organisation of work.

The survey covers all EU-27 Member States plus Iceland and Norway, and a representative sample of 27,250 workers above 16 years of age were interviewed over the telephone. Table 1 reports summary statistics for the variables of interest.

The first panel of Table 1 displays the information about **technology**. The OSH Pulse survey asks workers which type of technological devices they use in their main job. The question allows for multiple answers and the options include both basic technology such as desktop computers and laptops as well as more sophisticated devices, including wearables, AI machines and interacting robots. Not surprisingly,

the most widespread technology is *laptops and portable devices*, immediately followed by *desktop computers*. Seventy-eight per cent of workers declare to use some form of portable device at work, particularly in services and administration industries and among professionals and clerical workers. The use of basic technologies is quite widespread, and the distribution is pretty even across industries and occupations, as shown by Table A in the Annex. Nonetheless, data confirms that smartphones and portable devices are almost ubiquitous nowadays and are an integral part of many jobs regardless of the place of work and the workers' skills. Table A reports that one in three unskilled workers and 60% of farmers use a portable device in their main job. Reversely, the use of more advanced technologies is still limited to specific industries and generally more concentrated among professionals and skilled workers. In particular, wearables are mostly used in ICT and finance, manufacturing and engineering, and commerce and transportation sectors. AI machines and interacting robots are used by less than 5% and 3% of workers, respectively, and they are also mainly concentrated in manufacturing and engineering. It is not at all odd to find such lower percentages considering that so far these technologies are still in a testing phase and require major investments in both capital and managerial and organisational efforts and therefore are most likely to be taken up by large enterprises, whose workers are underrepresented in the OSH Pulse survey sample. Indeed, 70% of the workers in the sample work for companies with fewer than 250 employees. As for the occupations mainly exposed to advanced technologies, Table A shows that there is a slight prevalence among professional, skilled workers and farm workers.

Crucial for this study is the information about the **workplace**. The survey asks workers to identify their workplace based on 'the locations workers have worked for most of the time in the past 12 months'. Table 1 shows that 65% of respondents work at the employers' premises, 18% work from home and the remaining 17% are almost equally split among work at clients' premises (6%), car or other types of vehicles (4%), outside sites (6%) and public spaces (2%). For the purpose of our empirical study, all workers who perform their duties away from the employers' premises are considered remote workers, that is, above one-third of our sample consists of remote workers. The rationale behind this choice moves away from the task approach literature, which focuses mainly on the characteristics of the task performed by the worker as a condition to exercise power over the worker through the use of technology. On the contrary, it puts the emphasis on the exercise of control per se, with the hypothesis that workers who are carrying out their jobs outside the traditional working place (i.e. the employers' premises), and potentially also using personal devices, may be more exposed to forms of intrusive surveillance, which in turn may involve increased psychosocial risks and can negatively impact on workers' health. The survey does not contain information about the use of personal devices, but clearly asks if the organisation uses any of the technology in place to supervise or monitor behaviours.

Panels 3 and 4 present the variables related to the presence of psychosocial and health risks in the workplace. **Psychosocial risks** include all the aspects related to design, management and organisation of work that may generate mental health issues (such as stress, anxiety and depression) (EU-OSHA, 2014; Eurofound, 2022). The OSH Pulse survey collects six variables on psychosocial risks, namely: severe time pressure or work overload; violence or abuse from customers, patients, pupils, etc.; harassment or bullying; poor communication or cooperation within the organisation; lack of autonomy or influence over the work process; and, finally, other causes of stress. Severe time pressure or work overload has been reported by the majority of workers (45%), followed by poor communication and cooperation (27%) and other forms of stress (28%). When looking in detail at the different occupations (see Table A, Annex), no striking differences emerge, and there is a wide consensus about time pressure and work overload as the highest stress factor. However, sales and services occupations, considering the nature of their jobs involves direct contact with people, report also a higher percentage of violence, harassment and verbal abuse, while semi-skilled workers report a high risk level related to lack of autonomy.

Table 1: Summary statistics of variables of interest

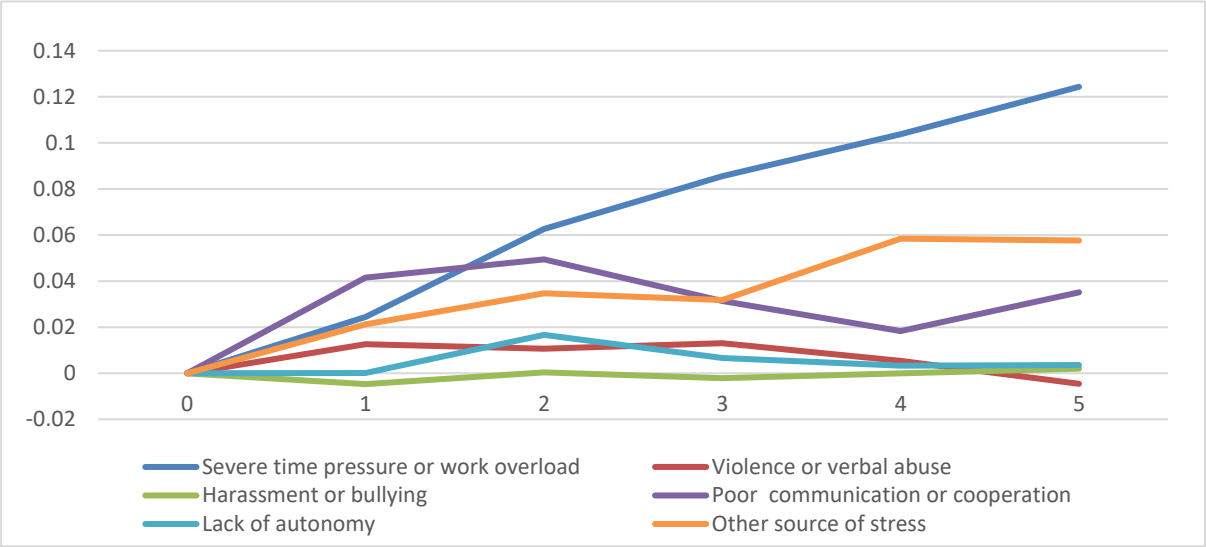
	Mean (1)	SE (2)	Min (3)	Max (4)	N (5)
1. Technologies					
Desktop computers	0.57	0.49	0	1	27,234
Laptops, tablets, smartphones, portable devices	0.78	0.42	0	1	27,234
Wearable	0.13	0.34	0	1	27,234
Broadband technology	0.55	0.50	0	1	27,234
AI machine	0.06	0.24	0	1	27,234
Interacting robots	0.03	0.18	0	1	27,234
2. Workplace					
Employers' premises	0.65	0.48	0	1	27,073
Clients' premises	0.06	0.24	0	1	27,073
Vehicle	0.04	0.20	0	1	27,073
Outside site	0.06	0.23	0	1	27,073
Home	0.18	0.38	0	1	27,073
Public space	0.02	0.15	0	1	27,073
3. Psychosocial risks					
Severe time pressure or work overload	0.45	0.50	0	1	27,071
Violence or verbal abuse	0.15	0.36	0	1	27,169
Harassment or bullying	0.07	0.26	0	1	27,138
Poor communication or cooperation	0.27	0.44	0	1	26,979
Lack of autonomy	0.17	0.37	0	1	26,864
Other source of stress	0.28	0.45	0	1	27,022
Psychosocial Indicator	1.37	1.37	0	6	27,234
4. Health outcomes					
Stress, depression or anxiety	0.28	0.45	0	1	27,234
Bone, joint or muscle pain	0.30	0.46	0	1	27,234
Infectious diseases	0.23	0.42	0	1	27,234
Headaches, eyestrain	0.36	0.48	0	1	27,234
Accident or injuries	0.05	0.23	0	1	27,234
Overall fatigue	0.38	0.49	0	1	27,234
Another health problem related to your work	0.06	0.25	0	1	27,234
None of these	0.31	0.46	0	1	27,234
Health indicator (Note: exclude 'None of these')	1.67	1.57	0	7	27,234
5. Organisational model					
Determine the speed or pace of your work	0.58	0.49	0	1	26,700
Increase surveillance of you at work	0.43	0.50	0	1	26,359
Supervise or monitor your work and behaviour	0.29	0.45	0	1	26,603
Automatically allocate tasks or working time or shifts	0.31	0.46	0	1	26,752
Have your performance rated by third parties	0.32	0.47	0	1	26,373
Monitor heart rate, blood pressure, postures	0.09	0.28	0	1	26,829
Organisational model indicator	1.96	1.44	0	6	27,234
6. OSH preventive measures					
Awareness raising on health and safety	0.62	0.49	0	1	26,827
Access to counselling or psychological support	0.42	0.49	0	1	26,430
Information and training on wellbeing and coping with stress	0.44	0.50	0	1	26,755
Consultation of workers about stressful aspects of work	0.44	0.50	0	1	26,657
Other measures to address stress at work	0.30	0.46	0	1	26,375

Source: Author's elaboration based on EU-OSHA OSH Pulse survey, unweighted

One may wonder how technology interacts with psychosocial risks. With the aim of answering this, a technology adoption indicator has been created by summing up all the types of technology listed in Table 1, panel 1, used by each worker. The indicator is a cumulative index that may take value from 0 to 6 and it is used to proxy the level of technological exposure of workers. Figure 1 shows the relative difference for each psychosocial risk factor considered between no technology and the adoption of one or multiple technologies. Although the total number of technologies reported by the survey is six, the

respondent number in the sample reporting the use of all six technologies is quite small and cannot be considered as representative enough. For this reason, in both Figures 1 and 2, the technology adoption indicator reported by the horizontal axis goes up to 5.

Figure 1: Psychosocial risks and technology adoption



Source: Author's elaboration based on EU-OSHA OSH Pulse survey

As shown by Figure 1, the *time pressure or work overload* risk factor shows an abrupt increase in line with the number of technologies used, and similar increasing trends are shown also by *poor communication or cooperation* and *other source of stress*. Similarly, technology seems also to increase the risk of *lack of autonomy*, though the magnitude is relatively smaller. Reversely, technology adoption seems to bring beneficial effects in reducing both violence and harassment. Indeed, if uncontrolled technology may prioritise efficiency at the expense of workers' wellbeing, generating excessive pressure and work overload or isolating workers (Eurofound, 2020a; Todolí-Signes, 2021; Baiocco et al., 2022), it may have a positive effect by creating a barrier that protects workers from abusive behaviours by third parties.

Exposure to psychosocial hazards may have direct consequences for workers' health conditions. The OSH Pulse survey contains evidence on **health outcomes** associated with the use of digital technologies and surveillance in the workplace. The survey asks about health issues that occurred in the past 12 months. Panel 4 of Table 1 shows all the detailed information asked on health outcomes. It is possible to isolate mental health issues (stress, depression, anxiety) from MSDs and accident or injuries. In line with other findings in the literature, in particular for teleworkers, the OSH Pulse survey data also report higher levels of overall fatigue and headaches and eyestrain (Samek Lodovici et al., 2021). According to our sample and as described by Table 2, remote workers report similar levels of mental health issues with respect to in-place workers, and higher values for MSDs and headaches and eyestrain. This could be explained by the lack of ergonomic furniture and equipment, the use of portable and mobile ICT devices with smaller screens, and virtual or small keyboards, as well as by performing the job activity in a work environment not fit for work purposes (i.e. cars, private houses, public spaces, etc.). Indeed, as reported by EU-OSHA (2017, 2018), mobile ICT equipment, in contrast to desktop devices, are often not ergonomically sound and fit for long working hours and may increase both MSDs and eyestrain and headaches. In general, all workers reported high levels of overall fatigue.

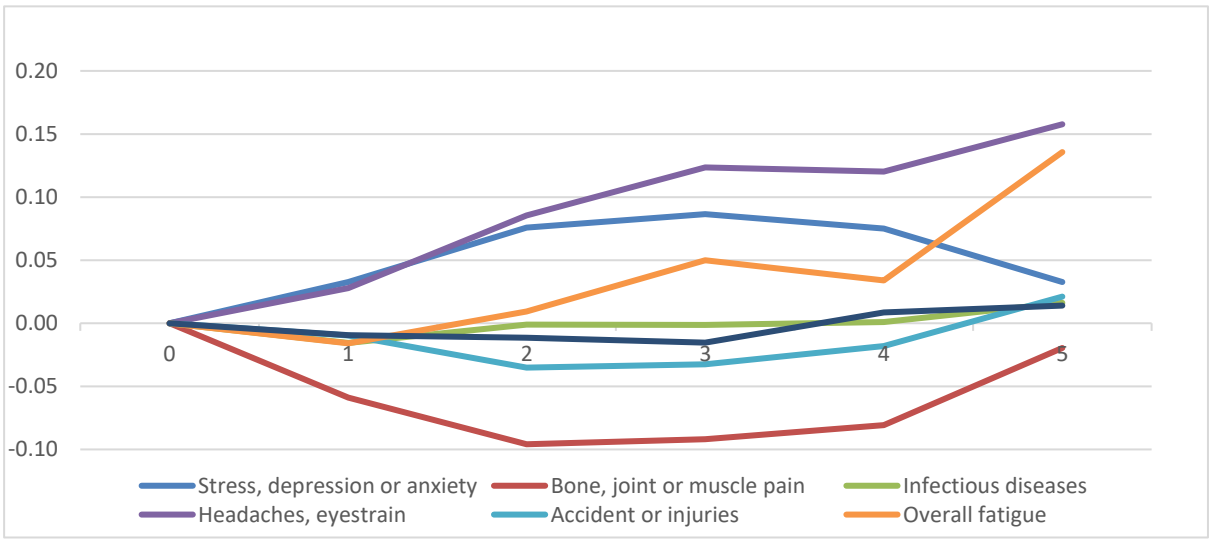
Table 2: Health outcomes for in-place and remote workers

	Workers at employers' premises	Remote workers
Stress, depression or anxiety	28.25%	28.40%
Bone, joint or muscle pain	28.79%	31.47%
Infectious diseases	24.81%	20.65%
Headaches, eyestrain	35.75%	36.65%
Accident or injuries	5.04%	6.14%
Overall fatigue	38.65%	37.47%
Other	6.23%	6.90%

Source: Author's elaboration based on EU-OSHA OSH Pulse survey

Figure 2 looks at the impact of technology adoption on health outcomes. An interesting result is that while headaches and eyestrain and overall fatigue display a positive correlation trend with the increasing use of technology, the opposite is true for bone, joint and muscle pain and accident or injuries. Stress and anxiety instead shows a slightly concave distribution, reporting an initial upward trend with the increasing use of technologies that reduces after the introduction of a third technology. A possible explanation may be found in the decreasing marginal importance of additional technologies in terms of generating stress and anxiety, even more if the additional technology is a general purpose one, such as broadband technology.

Figure 2: Health outcomes by degree of technology adoption



Source: Author's elaboration based on EU-OSHA OSH Pulse survey

These results are even more interesting when combined with the findings about remote workers reported in Table 2. Indeed, the data show that remote workers report higher level of MSDs with respect to in-place workers (workers at the employers' premises). However, the overall figures show that technology decreases the risks for MSDs as well as for accidents and injuries. The results are driven by a sharp decrease in the levels reported for bone, joint and muscle pain particularly by workers in labour-intensive industries such as agriculture and mining, manufacturing and transport.

These results are coherent with the findings on the impact of smart digital systems and technologies in preventing OSH risks especially for workers in high-risk sectors (EU-OSHA, 2022d, 2022e). The implementation of technologies within OSH monitoring systems capable of identifying and assessing

risks may minimise the consequences of harm and facilitate accident assistance, reporting and investigation, and improve workers' wellbeing and safety at the workplace. However, at the same time, OSH monitoring systems may entail massive and intrusive surveillance of workers that may generate stress and anxiety and lead to job dissatisfaction and frustration over technology. In order to prevent such negative outcomes and guarantee the successful implementation of safe OSH monitoring systems, it is essential that workers are involved in the definition and adoption of such systems, that they are correctly and timely informed about their rights and the use of their data, so as to set the basis for a cooperative exchange between worker and employers and ensure a sufficient level of trust in technology (EU-OSHA, 2022d, 2022e). Indeed, as confirmed also by empirical investigation, the optimal outcome from technology adoption largely depends on employees' acceptance of the technology and their involvement in the process of selection and implementation of technology (Jacob et al., 2019).

Certainly, technology is not neutral, and the way it is implemented could generate diametrically opposite results both in terms of efficiency and improvement of working conditions and OSH. There is an increasing use of digital tools in the workplace that depend on ever-more pervasive surveillance technologies and create trade-offs between higher efficiency and profits and security and privacy. Surveillance organisational models are characterised by an extensive use of control over workers that eventually influences work organisation and generates a series of risks and challenges related to performance monitoring, intensification of work, and working relationships and communications.

The OSH Pulse survey collects data on the impact and the risks associated with the use of technology at work. It asks if the use of digital technologies increases workload, determines the speed or pace of work, reduces autonomy, increases surveillance or results in working alone. Furthermore, it also asks for which purposes the organisation introduced digital technologies. Namely, to supervise and monitor work or behaviour, automatically allocate tasks or shifts, rate performance by third parties, monitor working environment (noise, chemicals, dust, etc.), and monitor workers' heart rate, blood pressure, posture and so on. Each of these variables is a dichotomous variable that takes value 1 if reported by the worker, zero otherwise. According to Table 1, the highest impact of the use of digital technologies is on the speed or pace of work as reported by 58% of the workers, followed by increased surveillance reported by 43% of workers. When instead workers are asked for which purpose the organisation introduced digital technologies, rating by third parties scores the highest, in line with findings from Wu et al. (2019), closely followed by automatic allocation of tasks or shifts and supervision and monitoring.

To analyse the combined effects of technology adoption and implemented changes in work organisation, an indicator to proxy the **organisational model** applied is created by summing up a subset of the dichotomous variables listed above. Using as a reference the main literature on algorithmic management (Shapiro, 2017; Kellogg et al., 2020; Wood, 2021; Baiocco et al., 2022) and data-driven management (McAfee and Brynjolfsson, 2012; Bloom et al., 2013; Brynjolfsson and McElheran, 2016), the organisational model indicator analyses how managerial practices are shaped based on employers' purpose of monitoring, discipline and control (De Stefano, 2016).

The variables used to build the organisational model are presented in panel 5 of Table 1. The cumulative index takes value from 0 to 6 and gives a proxy of the degree of surveillance embedded in technology use and worker management model.

The average value of the cumulative organisational model indicator is 1.96, suggesting a still limited diffusion of these practices. Table B in the Annex shows the distribution of the indicator by country and industry. Surveillance organisational models are found mainly in Administration, commerce and transport, Manufacturing and engineering, and the ITC and finance sectors and in countries with a history in BPO, such as Hungary and Malta, or with a strong ICT sector such as Lithuania and the Netherlands. This is in line with previous EU-OSHA research (EU-OSHA, 2022b). However, there is still scant empirical evidence on this topic and comparative data at European level are missing. The European Commission Joint Research Centre (JRC) collected data on the use of digital tools, digital monitoring and algorithmic management adoption in both digital and regular working spaces in Germany and Spain through the Algorithmic Management and Platform Work survey (AMPWork) (Fernández-Macías et al., 2023). Fernández-Macías et al. (2023) found that algorithmic management is more diffuse in high-technology and knowledge-intensive services sectors.

Looking at the interplay between surveillance organisational model and types of technology, the former is clearly more present when advanced technologies are adopted.[18] Indeed, for example, wearable technologies are electronic devices with sensor and computational capabilities that can be placed on workers' body or clothing and can collect continuous real-time information on workers' movements and posture, or on vital signs. Similarly, AI machines and interactive robots need to constantly update their information about the surrounding environment in order to take actions and work with a certain degree of autonomy. Clearly, these types of technology embed by default higher levels of monitoring and surveillance.

4.2 Empirical analysis

The aim of the empirical analysis is to test whether organisational models with a pervasive degree of surveillance have a direct impact on psychosocial risks and health outcomes. To do so, the organisational model indicator merges in a unique composite indicator two distinctive but intertwined aspects of the new data-driven management model: the surveillance practices and the algorithmic management. The surveillance practices capture the changes in the job quality and working conditions associated with the use of intrusive digital technologies. More specifically, the indicator uses information on the increase in workers' surveillance and monitoring of workers' behaviours. The algorithmic management describes the purpose of implemented digital technologies and the adoption of specific managerial practices, such as automatic allocation of tasks or shifts, monitoring of workers' vital signs and remote evaluation by third parties. The effects of algorithmic management on job quality are well documented in the context of digital labour platforms (Pesole et al., 2018; ILO, 2018, 2021; EU-OSHA, 2022f), however, as already mentioned, algorithmic management is increasingly adopted by regular business places with consequences that are not entirely explored (Baiocco et al., 2022; EU-OSHA, 2022c). Differently from the digital space, where algorithmic management practices were shaped, in more traditional settings these new business models and managerial practices must adapt to already existing working environments, and this may increase the stress factors for workers affected by the digital transition process (ILO, 2021; Baiocco et al., 2022).

Since the aim of the analysis is to test separately the impact on psychosocial risks and health outcomes of surveillance organisational models, and assuming that the theoretical approach is consistent for both dependent variables, the study estimates the same equations twice — once having the psychosocial risk indicator as dependent variable (Table 3) and secondly using the health outcomes indicator as dependent variable (Table 4). The psychosocial indicator is a cumulative index constructed as the sum of each stress factor reported in panel 3 of Table 1, and it may take values from zero to six. Similarly, the health outcomes indicator is a cumulative index computed as the sum of the health issues reported in panel 4 of Table 1, except the answer 'none of these'. The index takes values from 0 to 7. By assuming a linear relationship, the baseline models directly regress each dependent variable over the organisational model indicator and a dichotomous variable for remote workers that will give us an indication of the additional impact for remote workers, that is those who work away from the employers' premises. The results for the baseline model are presented in column 1 of each table. The second specification of the model in column 2 includes additional factors that take into account workers' characteristics and organisational factors such as workers' occupation, age and employment status as well as characteristics about firm size and place of work. And finally, the last specification, column 3, includes all indicators for OSH preventive measures adopted in the workplace. For the sake of clarity, the findings are discussed separately for each dependent variable.

4.2.1 Psychosocial risk indicator, cumulative index (0-6)

Table 3 presents the results of the ordinary least square (OLS) analysis that looks at the relationship between psychosocial risks and surveillance organisational model. The OLS model shows that surveillance organisational models are associated with an increase in psychosocial risks in all specifications. The organisational model indicator presents similar magnitudes and the same statistical significance in all three specifications of the OLS model, suggesting the relevant role played by the

[18] Desktop or mobile technologies could be pervasive and allow for monitoring and surveillance of workers. However, they do not need to be pervasive in order to function. On the contrary, wearables, AI machines and interactive robots need to be instructed and fed continuously by data in order to fulfil their scope.

adoption of surveillance and algorithmic management practices.[19] The use of surveillance technologies and algorithmic management practices increases the psychosocial risks at work by 0.210 points in the baseline case. Given that the organisational model indicator is built as a cumulative index of the (purposes of) technologies or practices adopted in the workplace, this result could be interpreted as well as that the additional adoption of a surveillance technology or algorithmic management practice increases the average level of stress at work by 0.210. The baseline model includes also a dummy variable indicating if workers work away from the employers' premises, the remote workers variable. The coefficient is negative and statistically significant, that is, remote workers seem to be less impacted than in-place workers in terms of psychosocial risks associated with the surveillance organisational model. While the finding on the impact of surveillance and algorithmic management practices on psychosocial risks at work is in line with other findings in the literature (Urzì-Brancati and Curtarelli, 2021; Bérastégui, 2021; Vignola et al., 2023), the result for remote workers appears less intuitive. Indeed, one would expect that workers under no direct control of employers will be more subject to forms of remote surveillance and may develop a higher level of stress in coping with working environments not fully adequate. A potential explanation for this finding could be that about half of the remote workers in the sample work from home and are professional, administrator or clerical workers. These workers may benefit from a greater autonomy and the possibility of work from home could, indeed, alleviate their work–life balance, reduce the commuting time and generally improving their life quality and mental health. To better untangle this relation, the second specification of the OLS model includes additional explanatory variables as factor of controls.

The second column of Table 3 reports the results from the model with additional information about workers and organisational factors. The effects of the organisational model indicator remain positive and statistically significant, proving that even when controlling for additional characteristics, surveillance and algorithmic management practices still play a role in worsening psychosocial risks in the workplace. The additional explanatory variables include information about workers' occupations and workplace, employment status, workers' age and firms' size. Workers have been arranged in five occupation groups based on similar tasks and skills requirements. The reference group in the analysis is *professionals and administrators*. According to the results reported in column 2, workers in clerical occupations and skilled workers are worse off than professionals and administrators while workers in sales and services are better off. And these results are confirmed also in the third specification (column 3) when preventive OSH measures are taken into account. These results are consistent with the data displayed by Figure 1. Indeed, the adoption of technology is positively related to an increasing lack of autonomy and severe time pressure and work overload, which may be more severe for clerical occupations than professionals, while it reduces the risks of harassment and verbal abuse to which sales and services workers are more exposed. Furthermore, clerical and skilled workers may be more exposed to task automation and procedures that allow for a deeper monitoring of the work performed, both in terms of speed and steps to follow, generating higher psychosocial risks for them.

Looking at workplaces separately allows us to better interpret the results for remote workers in the baseline specification. Indeed, remote workers who work from home, and account for half of the total sample of remote workers, show the highest coefficient and a negative correlation (-0.195). In other words, working from home reduces the psychosocial risks and drives the results for remote workers in the previous specification. This result persists also when taking into account the adoption of OSH preventive measures, although it reduces the magnitude (see column 3), and it contrasts with what was found by Urzì and Curtarelli (2021). However, the discrepancy in the findings could be explained by the use of different data. Indeed, Urzì and Curtarelli (2021) ran their analysis on the European Survey of Enterprises on New and Emerging Risks (ESENER) dataset that collects information at the establishment level and the survey is answered by either the owner or partner of the firm, the site manager, the health and safety officer, or the workers' representatives. This may introduce some bias on how psychosocial risks are perceived and reported about employees working from home. Still looking at the effects of different working places reported in the table, working at the clients' premises, or in a public space, increases the psychosocial risks. Although, as shown by column 3, when OSH preventive

[19] Given the intertwined nature between algorithmic management and surveillance practices, the OLS models have been tested to check for multicollinearity (i.e. high correlation between the explanatory variables). To check for multicollinearity, the variance inflation factors have been calculated. All independent variables reported a value of 1, that is, there is no correlation among the explanatory variables.

measures are factored into the model, both the coefficients and the significance diminish, hinting to a positive effect of OSH measures on reducing psychosocial risks and limiting the impact on health for remote workers.

Looking at organisational and structural factors, being self-employed reduces the psychosocial risks associated with surveillance organisational models but only when OSH preventive measures are factored into the equation (column 3), while the effect is not significant for older workers in both specifications. Although being self-employed shows in both specifications a negative correlation, that is being an independent worker partially shields workers from the intrusiveness of a surveillance organisational model, the result is only significant when OSH preventive measures are taken into account. A similar result is also found in Table 4 when looking at the effect of surveillance organisational models on health outcomes. In both cases the findings are a bit at odds, as normally OSH preventive measures do not directly target self-employed workers. Anticipating the results reported in Table 4, these findings may suggest two things. The first is that there are spillover effects of the implementation of OSH-related awareness-raising activities that may produce indirect outcomes by increasing workers' awareness, particularly for the solo self-employed who may often find themselves in a more vulnerable position (European Commission, 2021). Secondly, the majority of the self-employed are entrepreneurs who are most likely reporting about the OSH measures they apply in their workplace. When looking at companies' size, working for bigger firms gradually increases the psychosocial risks associated with surveillance organisational models as shown by the increasing coefficient for larger firms, confirming that surveillance organisational models are mostly implemented by larger enterprises.

Finally, the third specification takes account of the effect of the introduction of OSH measures on preventing or mitigating psychosocial risks. According to the results, all OSH measures considered have a mitigation effect on psychosocial risks, except for offering counselling and psychological support, which has a positive coefficient however not statistically significant. This result, although not significant, may hint at a prejudice towards the use of counselling and therapy in the workplace more than a real inefficiency of the measure. Indeed, the survey also asks if disclosing a mental health condition would have a negative impact on one's career, and in 11 Member States a majority of respondents 'strongly agree' or 'agree' that this might be the case (EU-OSHA, 2022g, Figure e2_1, p. 5).

Table 3: OLS regression results – Psychosocial risk indicator

VARIABLES	OLS Baseline (1)	Control factors (2)	OSH preventive measures (3)
Organisational model	0.210***	0.198***	0.208***
	(0.00606)	(0.00618)	(0.00646)
Occupations			
Clerical		-0.0875***	-0.0971***
		(0.0255)	(0.0264)
Sales and services		0.0546**	0.0395*
		(0.0226)	(0.0235)
Skilled		-0.0557*	-0.0591*
		(0.0293)	(0.0308)
Unskilled		0.00775	0.0062
		(0.0293)	(0.031)
Workplace			
Clients' premises		0.0939***	0.0911**
		(0.0363)	(0.0382)
Vehicle		0.0666	0.0544
		(0.0454)	(0.0472)
Outside site		-0.00769	-0.016
		(0.0359)	(0.0375)
Home		-0.195***	-0.164***
		(0.0212)	(0.0222)
Public space		0.149**	0.133**
		(0.0618)	(0.0635)
Remote workers	-0.0745***		
	(0.0168)		
Structural factors			
Self-employed		-0.0316	-0.0739***
		(0.0228)	(0.0238)

VARIABLES	OLS Baseline (1)	Control factors (2)	OSH preventive measures (3)
Workers > 55 years old		-0.0126	-0.0122
		(0.0204)	(0.0212)
Firm size			
1-9 employees		0.00213	0.0767
		(0.0583)	(0.0612)
10-49		0.163***	0.272***
		(0.0595)	(0.0625)
50-249		0.222***	0.356***
		(0.0605)	(0.0638)
250+		0.279***	0.443***
		(0.0605)	(0.0642)
OSH preventive measures			
Awareness-raising initiatives			-0.139***
			(0.0206)
Counselling or psychological support			0.0211
			(0.0208)
Information on wellbeing and coping with stress			-0.0925***
			(0.0213)
Workers' consultation			-0.106***
			(0.0201)
Other measure to address stress			-0.0762***
			(0.0206)
Constant	0.985***	0.860***	0.934***
	(0.0145)	(0.0605)	(0.0639)
Observations	27,073	26,308	24,367
R-squared	0.049	0.059	0.069

*Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

4.2.2 Health outcomes indicator, cumulative index (0-7)

The second regression model tests the effects of surveillance organisational models on health outcomes. Differently from the psychosocial risk indicator that captures the perceived risk factors related to the implementation of surveillance technologies and algorithmic management practices, the health outcomes indicator reports about health issues that have already occurred.

Table 4 presents the findings from testing the same OLS equations but using the health outcomes indicator as a new dependent variable and keeping the same independent variables as explanatory factors. The coefficient for the organisational model is positive and statistically significant, suggesting that a surveillance organisational model increases the volume of health issues reported. On average, health outcomes indicator increases by a factor of 0.165 when surveillance is intensified and additional algorithmic management practices are implemented. The magnitude and the significance of the coefficient remains the same even when controlling for additional structural factors and the implementation of OSH preventive or mitigating measures. The baseline model in column 1 includes the remote workers variable to control for differentiated impacts. The coefficient is not statistically significant and equals almost zero, denoting no difference in reported health issues for remote workers, differently from what was found for psychosocial risks.

Column 2 reports information about different occupation groups, workplaces and structural factors. In terms of occupation groups, clerical workers are the only group reporting significant coefficients in both specifications. With respect to professionals, clerical workers report a lower level of negative health outcomes, while unskilled workers are associated with the presence of negative health outcomes. This may be explained by the fact that many unskilled workers generally perform physical work and tend to report more frequently bone, joint and muscle pains, while clerical occupations carrying out mostly administrative and desk-based tasks may be more subject to similar health outcomes as the professionals, although reporting a lower level of stress and anxiety. However, those are speculations that should be better investigated by using more detailed information. Interestingly, when including in the model specification the adoption of OSH preventive measures, the association for unskilled workers is no longer statistically significant, reinforcing the positive effects of such measures on general health outcomes.

The effects of workplaces on health outcomes are like the ones reported for psychosocial risks, although smaller in magnitude and less significant. Working away from the employers' premises increases the average health reported outcomes almost for all workplaces except for the case of home-based workplaces. However, working from a vehicle or an outside site are not statistically significant. As found for psychosocial risks, the negative coefficient for working from home shows on average better health for those workers. When considering the effects of OSH preventive measures (column 3), only working from a public space and at the clients' premises remain significant, which is consistent with the fact that those are the two working environments where OSH preventive measures cannot be (entirely) implemented.

When looking at structural factors, being self-employed reduces the association with bad health outcomes, although the variable is only significant in the specification that includes OSH preventive measures. Generally, OSH preventive measures are targeted to employees and are more effective towards them. However, this finding seems to be driven by information and awareness activities to help cope with stress and health and safety and it seems plausible that this type of more generic knowledge could overcome the boundaries of the workplace and generate indirect positive effects also for self-employed workers, particularly for the solo self-employed. This perhaps suggests how new technologies in the workplace and at work in general may have an effect in reshaping the traditional differences among workers in different working environments and employment status and addressing the debate on whether there is a need for rethinking some of the work categories and extending workers' protection on the grounds of the real risks encountered more than on the basis of their employment status. In addition, as already stated in the previous section, the positive outcome may be associated with the fact that 'self-employed' actually captures entrepreneurs who report on the adoption of OSH measures in their workplaces. Being an older worker also seems to reduce on average the negative health outcomes reported, while firm size does not exert any effect. Finally, all OSH preventive measures taken into consideration have a positive effect on reducing the average association with negative health outcomes.

In conclusion, the empirical analysis shows that surveillance organisational models affect both psychosocial risks and health outcomes for workers. Being a remote worker, in particular working from home, reduces the effects of both surveillance and algorithmic management practices on psychosocial risks while it has a smaller or no implication for health outcomes. However, when detailing the place of work, working at the clients' premises and in a vehicle increases the association with psychosocial risks and negative health outcomes. In general, OSH preventive measures prove to be effective both in preventing the psychosocial risks and limiting the negative health outcomes associated with the use of surveillance technologies and algorithmic management practices.

Table 4: OLS regression results – Health outcomes indicator

VARIABLES	OLS Baseline (1)	Control factors (2)	OSH preventive measures (3)
Algorithmic management	0.165***	0.162***	0.172***
	(0.00872)	(0.00694)	(0.00723)
Occupations			
Clerical		-0.0510*	-0.0568*
		(0.0294)	(0.0305)
Sales and services		0.0201	0.0142
		(0.0259)	(0.0269)
Skilled		0.0436	0.0383
		(0.0349)	(0.0366)
Unskilled		0.0591*	0.0386
		(0.0352)	(0.0369)
Workplace			
Clients' premises		0.114***	0.128***
		(0.042)	(0.0439)
Vehicle		0.0395	0.00519
		(0.0534)	(0.0554)
Outside site		-0.0434	-0.057
		(0.0432)	(0.0447)
Home		-0.0527**	-0.00471
		(0.0254)	(0.0265)
Public space		0.146**	0.181**

VARIABLES	OLS Baseline (1)	Control factors (2)	OSH preventive measures (3)
		(0.0711)	(0.0738)
Remote workers	-0.00176		
	(0.0379)		
Structural factors			
Self-employed		-0.0161	-0.0639**
		(0.0283)	(0.0293)
Workers > 55 years old		-0.109***	-0.102***
		(0.0238)	(0.0247)
Firm size			
1-9 employees		-0.0441	-0.0249
		(0.081)	(0.085)
10-49		-0.0243	0.036
		(0.082)	(0.0861)
50-249		-0.00244	0.0707
		(0.083)	(0.0874)
250+		-0.0641	0.0537
		(0.0829)	(0.0876)
OSH preventive measures			
Awareness-raising initiatives			-0.0793***
			(0.0238)
Counselling or psychological support			-0.0610**
			(0.024)
Information on wellbeing and coping with stress			-0.0841***
			(0.0247)
Workers' consultation			-0.134***
			(0.0236)
Other measure to address stress			-0.0883***
			(0.0241)
Constant	1.355***	1.410***	1.539***
	(0.0272)	(0.0829)	(0.0875)
Observations	27,073	26,308	24,367
R-squared	0.023	0.025	0.034

*Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0*

5. Policy implications and conclusions

Based on the EU-OSHA OSH Pulse survey data, 78% of the total workers interviewed declared to be under some form of data-driven management. That is, they report to either having digital technologies determining their speed of work, or monitoring and surveilling their work, or assigning them tasks or shifts, or evaluating their work or, finally, monitoring their vital signs. Using information about the introduction of surveillance technologies and algorithmic management practices, the effects of new technologies and new organisational models have been tested on workers' health outcomes and perceived psychosocial risks. Additionally, the empirical investigation tested the differences among workers performing their duties at the employers' premises and remote workers. The empirical analysis shows that surveillance organisational models lead to higher psychosocial risks and worse health outcomes. It confirms also that being a remote worker, in particular when working from home, reduces the effects of both surveillance and algorithmic management practices on psychosocial risks while it has smaller or no implication for health outcomes. However, working at the clients' premises and in a vehicle increases the association with higher psychosocial risks and worse health outcomes. Finally, the regression model also tests the effects of the introduction of OSH preventive measures. They prove to be effective both in preventing or limiting the psychosocial risks and reducing the health outcomes indicator associated with use of surveillance technologies and algorithmic management practices.

The findings of this study are in line with the literature on the adoption of surveillance technologies and algorithmic management practices and workers' exposure to psychosocial risks and health outcomes. Alike Urzì and Curtarelli (2021), the study reports a positive association between management technologies and psychosocial risks, and in both studies the mitigating effects of OSH preventive measures are confirmed. Interestingly, among the different OSH preventive measures analysed, both studies find that the provision of psychological support and counselling seems to be the less effective

of other OSH measure taken into account. Possibly, this is a result driven by the persistence of prejudices in accessing psychological support and counselling in the workplace as reported by the OSH Pulse survey when asking if disclosing a mental health condition would have a negative impact on one's career. In 11 Member States a majority of respondents 'strongly agree' or 'agree' that this might be the case. Differently from what found by Urzì and Curtarelli (2021), when looking at remote workers who work from home the study finds that they report lower psychosocial risks than workers at the employers' premises. The potential explanation for this difference could arise from two sources. First, Urzì and Curtarelli (2021) ran their analysis on the ESENER establishment survey data that contains information at the establishment level and the survey is answered by either the owner or partner of the firm, the site manager, the health and safety officer, or the workers' representatives. This may introduce some bias on how psychosocial risks are perceived and reported about employees working from home. Secondly, the distribution of the OSH Pulse survey for workers who work from home is skewed towards professionals and administrators. That is, among remote workers who work from home, professionals and administrators are overrepresented, which may in part explain the negative association between remote workers and psychosocial risks, considering that they normally benefit from greater autonomy, improved work–life balance and not being exposed to face-to-face contact with third parties, and therefore may reap the benefit of a more flexible work arrangement without bearing the cost of increased surveillance and algorithmic management.

In conclusion, the empirical analysis confirms that the use of surveillance technologies and algorithmic management practices increases psychosocial risk and negative health outcomes and that, however, there is a role to play for institutions to support and promote the adoption of OSH measures in working contexts where such technologies are deployed, which are proved to have preventive and mitigating effects.

Currently, the only explicit pieces of legislation introducing measures addressed at regulating the use of algorithms in the workplace are the directive proposal to improve the working conditions of people working through digital labour platforms, which dedicates a full chapter to the use of algorithms in the workplace, and the proposal for the Artificial Intelligence Act, which addresses the use of AI in the workplace. Both legislations are still following the legislative process, therefore a final law is not available yet. However, some principles on how to regulate the consequences of the introduction of algorithmic management and surveillance technologies in the workplace could be already anticipated.

The proposed directive, although restricted to the scope of digital labour platforms, clearly tackles the issue of employment status for technologically dependent workers, implicitly recognising that technology may blur the boundaries between traditional definitions of different employment status. This is fundamental for the application of OSH regulations, given that as of today only employees are covered by them. This study has shown that although in general the self-employed are less affected by surveillance organisational models, solo self-employed persons may be vulnerable to the adoption of algorithmic technologies and therefore further analysis needs to be undertaken to deeply understand how far these new organisational models could extend their control and therefore the health and psychosocial risks associated also for workers in non-standard working arrangements. However, the directive proposal extends OSH regulations to platform workers, but excludes the self-employed and those in alternative work arrangements. That is, it does not advance the current health and safety acquis, in the sense of enlarging the crowd of workers who can access OSH regulations.

A common principle present in both the proposed directive and the AI Actis the need to mitigate the negative consequences of algorithmic management by increasing transparency, introducing human supervision, and foreseeing a duty to consult workers and their representatives before the introduction of algorithmic and AI-based systems in the workplace.

Relying instead on what is already enforced and available at EU level, the GDPR remains a potential safeguard for workers' data and adverse effects and discrimination stemming from defective algorithms, although with the limitations already explained in this report.

At Member State level, some initiatives, in particular about the transparency of the algorithms, have been undertaken in Spain and in Italy, where the latter also explicitly extended the OSH legislation to riders. As per the introduction of surveillance technologies in the workplace, the regulatory framework differs among Member States, where some foresee agreement or co-determination to adopt new technologies in the workplace (i.e. Germany, the Netherlands, Austria, Finland and Sweden), while

others require only consultation (Belgium, France and Romania) or by collective agreement (i.e. Italy). The results of this study clearly point towards an increasing adoption of data-driven worker management and surveillance technologies, for both remote and in-place workers. Similarly, the mitigating effects of OSH preventive measures have been confirmed by the empirical analysis. The use of algorithmic management and surveillance technologies in the workplace affects workers' privacy and data rights, may hamper their freedom of association and worsen their working conditions as well as affect their mental and physical health. Intrusive and non-transparent surveillance practices must be regulated and a thorough dedicated regulation on algorithmic management at work should be discussed in the policy debate.

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Annex

Table A: Prevalence of psychosocial risk by occupation

Occupations	Severe time pressure or work overload	Violence or verbal abuse	Harassment or bullying	Poor communication or cooperation	Lack of autonomy	Other source of stress
Professional and technical occupations	47.75%	15.17%	7.08%	25.28%	16.76%	30.32%
Higher administrator occupations	52.71%	14.24%	6.45%	27.83%	17.05%	30.18%
Clerical occupations	43.18%	11.38%	5.99%	26.75%	18.65%	22.98%
Sales occupations	41.21%	19.57%	6.37%	24.30%	15.95%	27.98%
Service occupations	45.80%	22.74%	10.14%	27.01%	19.70%	30.47%
Skilled worker	43.06%	14.42%	7.71%	27.45%	18.44%	27.75%
Semi-skilled worker	46.18%	16.02%	6.94%	28.17%	23.90%	30.71%
Unskilled worker	40.61%	10.71%	7.61%	30.72%	14.36%	25.03%
Farm worker	48.84%	10.15%	6.98%	21.19%	12.34%	28.13%
Total	45.96%	15.69%	7.33%	26.38%	17.72%	28.75%

Source: Author's elaboration based on EU-OSHA OSH Pulse survey

Table B: Organisational model indicator by sector and country

Country	Administration and support services	Agriculture, mining, gas, electricity, water supply	Manufacturing or engineering	Construction or building	Commerce, transport, accommodation or food services	ICT and finance	Services to education, health or social care	Social, cultural, personal services
Hungary	2.62	1.84	2.48	2.06	2.62	2.52	2.39	2.33
Lithuania	2.55	1.89	2.24	1.71	2.56	2.55	2.22	1.96
Bulgaria	2.53	1.73	2.17	1.34	2.33	2.24	2.10	1.99
Netherlands	2.44	2.17	2.35	2.26	2.24	2.30	2.12	2.17
Greece	2.40	2.16	1.73	1.58	2.42	2.08	1.81	2.22
Malta	2.37	2.50	2.21	2.62	2.78	2.40	2.44	2.76
Republic of Cyprus	2.34	1.29	1.75	1.77	2.41	2.47	2.20	2.07
Latvia	2.30	2.09	1.82	2.16	2.45	2.26	2.02	1.89
Ireland	2.25	1.88	2.36	2.28	2.25	2.26	2.43	2.31
Luxembourg	2.24	2.20	1.97	2.16	2.50	2.23	2.15	2.16
Portugal	2.20	2.00	2.04	2.18	2.09	2.26	2.15	2.01
Croatia	2.17	1.90	1.75	1.45	2.35	2.32	1.94	1.49
Estonia	2.16	2.13	1.97	1.82	2.33	2.09	1.76	1.76
Slovakia	2.12	1.62	2.35	1.76	2.28	2.30	1.96	1.89
Denmark	1.97	1.65	1.77	1.35	1.88	1.97	1.84	1.58
Belgium	1.96	2.13	1.80	1.55	2.02	1.97	1.82	1.56
Austria	1.91	2.02	2.10	1.85	1.98	1.87	1.92	1.96
Romania	1.91	1.98	2.28	1.99	2.20	1.98	2.12	1.99
Italy	1.86	1.62	1.61	1.54	1.80	1.91	1.84	1.39
France	1.81	1.68	1.67	1.77	1.97	1.93	1.77	1.30

Country	Administration and support services	Agriculture, mining, gas, electricity, water supply	Manufacturing or engineering	Construction or building	Commerce, transport, accommodation or food services	ICT and finance	Services to education, health or social care	Social, cultural, personal services
Finland	1.79	1.94	1.59	2.05	2.05	1.90	2.28	2.05
Poland	1.79	1.77	2.04	1.19	2.07	1.67	1.53	1.56
Spain	1.78	2.00	1.96	1.96	2.03	2.24	2.04	1.80
Slovenia	1.77	1.53	1.94	1.42	1.99	1.94	1.71	1.50
Norway	1.63	1.76	1.71	1.52	2.25	1.63	1.81	1.80
Germany	1.55	1.64	1.53	1.41	1.80	1.65	1.54	1.17
Czechia	1.53	1.44	1.60	1.21	1.63	1.57	1.32	1.23
Iceland	1.36	1.07	1.29	1.25	1.34	1.35	1.41	1.46
Sweden	1.34	1.48	1.46	1.80	1.63	1.48	1.58	1.42

Source: Author's elaboration based on EU-OSHA OSH Pulse survey

Table C: Technology adoption cumulative index by type of technology and industry

	Desktop computers	Laptops, tablets, smartphones, portable	Wearable	Broadband technology	AI Machine	Interacting robots	Total
Administration and support services	3.06	3.08	3.52	2.97	3.62	3.49	3.01
Agriculture, mining, gas, electricity, water supply	3.17	3.12	3.95	3.34	4.38	4.55	2.91
Manufacturing or engineering	3.24	3.15	3.56	3.14	4.13	3.93	3.10
Construction or building	2.94	2.97	3.42	2.83	3.71	4.34	2.76
Commerce, transport, accommodation or food services	3.20	3.29	3.85	3.27	3.95	5.12	3.10
ICT and finance	3.11	3.04	3.64	3.01	3.38	3.71	3.03
Services to education, health or social care	3.04	2.93	3.34	2.99	3.86	3.71	2.87
Social, cultural, personal services	2.83	2.77	3.29	2.81	3.52	3.71	2.58

Source: Author's elaboration based on EU-OSHA OSH Pulse survey

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.

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