SMART DIGITAL MONITORING SYSTEMS FOR OCCUPATIONAL SAFETY AND HEALTH: INCLUSION AND DIVERSITY AT THE WORKPLACE

Inclusion and diversity in the workplace: The benefits of digital OSH monitoring systems

The implementation of digital OSH monitoring systems, such as wearables or phone apps in the workplace, can strengthen **inclusion and diversity in the workforce** by providing additional support to or addressing the needs of specific groups of workers.[1],[2],[3]

Employment rates for certain groups of workers, namely people with disabilities,[4] older workers (aged 55–64),[5] and migrant workers[6] are much lower than for the general population. There are many barriers to the labour market integration of these groups, and overcoming these requires a variety of policy instruments. Nevertheless, integration could also be strengthened through improving and adjusting OSH policies. This is especially important when general OSH provisions in place are designed with able-bodied workers in mind.[7] Therefore, **tailored support and the development of more accessible workplaces** through the use of new OSH monitoring solutions could be beneficial to a range of groups of workers, including older workers, migrant workers with low language skills, pregnant women, neurodiverse[8], workers, those with health issues, physically disabled workers, lone workers, and inexperienced workers.[9]

The rights of **people with disabilities or those or have special needs** are enshrined in equal treatment legislation and OSH legislation.[10] Under OSH legislation, employers have certain obligations, including ensuring that risk assessments and preventive measures guarantee safety and health in the workplace. Employers must also adapt workplaces to the needs of vulnerable groups of workers, including workers with disabilities.[11]

Adding another layer of complexity, against the background of Europe's **ageing population and workforce,** the question of promoting healthy ageing and wellbeing in the workplace is a key focus in terms of ensuring inclusion and diversity there. Health issues tend to build up during the course of an individual's life and work and their impact remains after retirement[12]. This is especially true for workers carrying out stressful, physically

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[1] Brinzea, V.-M. (2019). Encouraging neurodiversity in the evolving workforce: The next frontier to a diverse workplace. *Scientific Bulletin-Economic Sciences, 18*(3), 13-25.

[2] Lloyd-Jones, B., Bass, L., & Jean-Marie, G. (2018). Gender and diversity in the workforce. In M. Y. Byrd & C. L. Scott (Eds), *Diversity in the workforce* (2nd ed.) (pp. 81-106). Routledge.

[3] Parry, E., & Tyson, S. (Eds) (2010). *Managing an age-diverse workforce*. Springer.

[4] European Trade Union Confederation. (2020). *ETUC position on a new European Disability Strategy*. https://www.etuc.org/sites/default/files/circular/file/2020-11/ETUC%20position%20on%20a%20new%20European%20Disability%20Strategy%20updated%202%20%281%29.pdf Employment rates for people with disabilities were 48.1% vs 73.9% for the general population in 2020.

[5] Eurofound. (2023). *Ageing workforce*. https://www.eurofound.europa.eu/topic/ageing-workforce Older workers had an employment rate of 55.3% vs 66.6% of those aged 15-64 as a whole in 2016.

[6] Eurostat. (2021). *Migrant integration statistics – labour market indicators*. In 2020, the EU employment rate for people aged 20-64 years was 61.9% for those born outside the EU, and 73.5% for the native-born population as well as for people born in another EU Member State.

[7] Equality and Human Rights Commission. (2007). *Health and safety for disabled people and their employers: Case study examples*. https://lx.iriss.org.uk/sites/default/files/resources/Health%20and%20safety%20for%20disabled%20people%20and%20their%20employers.pdf

[8] Brinzea, V.-M. (2019). Encouraging neurodiversity in the evolving workforce: The next frontier to a diverse workplace. *Scientific Bulletin-Economic Sciences, 18*(3), 13-25.

[9] Ibid.

[10] EU-OSHA – European Agency for Safety and Health at Work, *Factsheet 53 - Ensuring the health and safety of workers with disabilities*, 2004. Available at: https://osha.europa.eu/en/publications/factsheet-53-ensuring-health-and-safety-workers-disabilities

[11] Ibid.

[12] Ferraro, K. F., Shippee, T. P., & Schafer, M. H. (2009). Cumulative inequality theory for research on aging and the life course. In V. L. Bengston, D. Gans, N. M. Pulney, & M. Silverstein (Eds), *Handbook of theories of aging* (pp. 413-433). Springer Publishing Company.

exhausting, and hazardous work, which can negatively affect healthy ageing. Therefore, a well-thought-out intervention may have long-term positive impacts on workers' health.[13]

When it comes to the needs of older workers, gradual loss of physical strength and stamina, as well as diminished cognitive performance should be considered when designing OSH interventions. This should ensure that the physical and cognitive burdens of tasks are kept to a minimum. For example, the use of **wearables** and monitoring systems facilitate the identification of tasks or situations perceived as being more hazardous or demanding for older workers, while also monitoring levels of physical or cognitive fatigue through indicators such as heart rate and stress levels. Coupling these physiological variables with environmental inputs (e.g. light, noise, temperature, vibration) enables decisions to be taken that reflect the physical state of workers. This information can be fed back to workers individually and, based on their consent, to their superiors, in order to enable them to adjust their workloads and design tailored support/measures (e.g. not exposing an older worker to working conditions that are known to lead to high fatigue and overexertion).[14] The use of such OSH monitoring systems, which combine professional and personal inputs and foster conditions in which workers remain productive and able to be part of the workforce for longer periods, could be further improved by adopting a preventive long-term data-driven approach.[15]

New OSH monitoring solutions can also increase the accessibility of some **occupations or concrete tasks** to workers with specific needs or characteristics. Exoskeletons that monitor stressors and vital signs help workers by **reducing the physical load when individuals engage in demanding activities**. This can be especially relevant for **people with physical disabilities or those who suffer from ill-health**.[16] Furthermore, OSH technology that communicates alerts not only by using acoustics but also vibrations or light can be useful for **workers with hearing impairments** in particular, but also for all workers operating in very noisy environments. **Neurodiverse workers** can benefit from an adapted working environment, for example by using noise-cancelling headphones if they are particularly sensitive to acoustic stimuli, or low arousal light and sound settings that transmit information about risks and hazards.[17] Adaptation of tasks in traditional high-risk sectors such as construction, e.g. through remote use of heavy equipment, may also be possible.

Many new monitoring systems can be used for training purposes, making training better, safer, and more tailored to workers' individual needs. To this end, the integration of **workers with a migrant background and with low language skills** in workplaces can be fostered by using cameras and AI as effective OSH training resources. These resources include video material and visual clues rather than text in order to make the training programme more understandable and accessible for those with limited language comprehension.[18]

Lone workers or **workers in hazardous locations** can be tracked through geo-tagging sensors, which reduces the risks resulting from working in isolation. The OSH of **inexperienced workers and the** onboarding of these workers can also be enhanced by using new monitoring solutions. For example, glasses with miniaturised video placed on the head, chest or shoulder may show a less experienced worker how a task should be performed, with the video supplemented by a voice-over describing the execution of a task for better

[13] Nilsen, C., Darin-Mattsson, A., Hyde, M., & Wastesson, J. W. (2021). Life-course trajectories of working conditions and successful ageing. *Scandinavian Journal of Public Health, 50*(5), 593-600. https://doi.org/10.1177/14034948211013279

[14] Lavallière, M., Burstein, A. A., Arezes, P., & Coughlin, J. F. (2016). Tackling the challenges of an aging workforce with the use of wearable technologies and the quantified-self. *Dyna, 83*(197), 38-43. https://doi.org/10.15446/dyna.v83n197.57588

[15] Ortet, S., Dantas, C., Machado, N., Tageo, V., Quintas, J., & Haansen, S. (2019). Pervasive technologies applied to the work environment: Implications for end-users: The foreground for SmartWork concerns and requirements. In *Proceedings of the 12th ACM International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '19)* (pp. 459–463). Association for Computing Machinery. https://doi.org/10.1145/3316782.3322769

[16] EU-OSHA – European Agency for Safety and Health at Work, *Occupational exoskeletons: wearable robotic devices and preventing work-related musculoskeletal disorders in the workplace of the future*, 2020. Available at: https://osha.europa.eu/en/publications/occupational-exoskeletons-wearable-robotic-devices-and-preventing-work-related

[17] Mpofu, E., Cagle, R., Chiu, C. Y., Li, Q., & Holloway, L. (2021). Digital tools applications to occupational health and safety for people with autism. In N. Ferreira, I. L. Potgieter, & M. Coetzee (Eds), *Agile coping in the digital workplace* (pp. 147-165). Springer.

[18] Cocca, P., Marciano, F., & Alberti, M. (2016). Video surveillance systems to enhance occupational safety: A case study. *Safety Science, 84*, 140-148. https://doi.org/10.1016/j.ssci.2015.12.005

guidance.[19] Finally, new OSH monitoring systems such as wearables with proximity sensors, may also enable workers at an increased risk of severe illness as a result of COVID-19 to reintegrate into the workplace.

Inclusion and diversity in the workplace and the use of digital OSH monitoring systems: Remaining challenges

Despite the considerable opportunities linked to new OSH monitoring systems in relation to improving inclusion and diversity in the workplace, significant challenges remain, particularly in relation to age, health, gender, race/ethnicity, and level of worker experience.

In terms of the increasing ethnic/racial diversity of workplaces, digital technologies still have certain limits in terms of accurately collecting and analysing the data of such a diverse workforce. For example, human-machine interfaces could misinterpret face, gestures, and voice signals. At the intersection of race/ethnicity and gender**, AI or ML algorithms** still have high rate of error for the facial recognition of black women between the ages of 18 to 30.[20] However, reliable, accurate, and unbiased data is crucial for AI, because its intelligence and capacity to achieve complex goals is heavily dependent on the input it receives. Other issues may arise in terms of language, for example the pronunciation of workers who are not native speakers may not be easily recognised by digital means, unless developers specifically work on these aspects. Lastly, in terms of health data, there are sometimes marked differences with regard to data related to blood samples and hormonal levels across different ethnic groups, which means that the same values for workers of different ethnic groups may in fact tell a very different story.[21] [22]

Limitations also exist in the case of OSH monitoring systems supporting **lone workers or workers in hazardous conditions/locations, particularly if they are inexperienced.** For example, these systems might fail to detect unsafe conditions or behaviours in a timely manner (e.g. drowsiness in truck drivers or not wearing safety equipment), and may also fail to locate a worker in distress due to the accuracy of sensor. Therefore, it is important to adopt these systems, but users should not entirely rely on them and abandon cautious and safe ways of approaching work.[23] Evidence suggests that digital systems, for example linked to the augmented workforce (e.g. exoskeletons, smart personal protective equipment), may make workers feel that they are invulnerable, making them over-confident in their abilities, which in turn could result in harm and accidents. A related, if separate, aspect relates to how digital monitoring systems communicate with workers, especially inexperienced workers, and how they provide them with alerts, reminders and warnings. This is certainly helpful, but there is a risk that this information could also distract workers, cause cognitive overload, and prove stressful due to the constant monitoring.

In terms of the ageing workforce, while the use of different sensors can help to obtain individualised health feedback, they may not accurately identify poor individual health. This is especially true in the case of working environments that may limit **sensor accuracy** because of interference (e.g. fire, dust, heat, or the presence of steel). Furthermore, even when information is accurately collected, it can be organisationally **challenging to analyse the data and to put into place structural measures** tailored to older workers. It is also important to note that OSH monitoring systems may **sometimes intensify work**, which causes harm to workers, **or de-intensify it,** which may lead to loss of muscle and bone density, as well as joint flexibility.[24]

As mentioned earlier, exoskeletons using digital monitoring systems can also help people suffering with **ill-health or those who have a disability**. However, exoskeletons present a number of potential risks, as they can result in new biomechanical constraints and risk factors for musculoskeletal disorders (MSDs). They can also hinder movement due to their size. In addition, they may cause discomfort and skin irritation, or even increase cardiovascular stress.[25] Furthermore, putting into place quick fixes at individual worker level might

[19] Lavallière, M., Burstein, A. A., Arezes, P., & Coughlin, J. F. (2016). Tackling the challenges of an aging workforce with the use of wearable technologies and the quantified-self. *Dyna, 83*(197), 38-43. https://doi.org/10.15446/dyna.v83n197.57588

[20] Furl, N., Phillips, P. J., & O'Toole, A. J. (2002). Face recognition algorithms and the other-race effect: Computational mechanisms for a developmental contact hypothesis. *Cognitive Science, 26*(6), 797-815. https://doi.org/10.1016/S0364-0213(02)00084-8

[21] Mullings, L., & Schulz, A. J. (2006). Intersectionality and health: An introduction. In A. J. Schulz & L. Mullings (Eds), *Gender, race, class, & health: Intersectional approaches* (pp. 3-17). Jossey-Bass/Wiley.

[22] Wood, S., Martin, U., Gill, P., Greenfield, S. M., Haque, M. S., Mant, J., Mohammed, M. A., Heer, G., Johal, A., Kaur, R., Schwartz, C., & McManus, R. J. (2012). Blood pressure in different ethnic groups (BP-Eth): A mixed methods study. *BMJ Open, 2*(6), Article e001598. http://dx.doi.org/10.1136/bmjopen-2012-001598

[23] Based on stakeholder consultations.

[24] EU-OSHA – European Agency for Safety and Health at Work, *Digitalisation and occupational safety and health - An EU-OSHA research programme*, 2019. Available at: https://osha.europa.eu/en/publications/digitalisation-and-occupational-safety-and-health-eu-osha-research-programme

[25] INRS. (2020). *Using exoskeletons at work : The message of prevention*. https://en.inrs.fr/news/exoskeletons-6-critical-points.html

shift the focus away from structural changes based on the hierarchy of controls that would make workplaces more welcoming for workers with disabilities.

Overall, apart from the specific examples noted above, there are a number of more general considerations concerning the use of new OSH monitoring systems. These relate to their psychosocial effects on workers resulting from factors such as constant monitoring or alienation from work but also issues concerning data. In particular, the collection of the health data of individual workers may raise concerns over **workplace discrimination**, as information on the digital devices could be used to inform decisions on recruiting, dismissing, or retaining staff.[26] Consequently, while data can be useful for monitoring health, it can also prove to be a double-edged sword, and the risk is that poor health could be used against workers.

How can the use of digital OSH monitoring systems improve inclusion and diversity in the workplace

OSH monitoring system can improve inclusion and diversity in the workplace, and can indeed prove a great equaliser, however there are still challenges that need to be addressed. In order to support this, the following five recommendations, which are interconnected, should be considered.

1. Use **OSH monitoring systems as tools to consistently improve OSH**, especially for workers with special needs, through structural workplace adaptations and corrective measures, adhering to the hierarchy of controls. It is especially important to develop a holistic approach to new OSH monitoring systems with clearly defined procedures and rules guiding them and to avoid 'quick fixes' at individual worker level while neglecting infrastructural changes that would make workplaces more inclusive. As part of structural changes, strategies to promote OSH and healthy ageing based on the feedback of monitoring data should be put into place.

2. Provide clear **examples, guidance and manuals** on how new monitoring systems can protect the needs of workers with disabilities and those with special needs.

3. **Train both** workers with special needs and management on the use of these systems and how to manage them, so that all parties involved are aware of their rights and obligations and the reasons why these systems are used, which is to protect workers with special needs and not penalise them or monitor them unnecessarily. This could reduce potential misunderstandings and the abuse of monitoring.

4. Ensure that **workers with special needs and worker representatives participate** in the design and implementation of OSH monitoring systems, which would promote a better understanding of their purposes and application and address any potential concerns, notably in terms of discrimination based on the data collected from individual workers. The creation of open channels between workers with special needs, their representation, and management through which concerns could be formally raised would be also useful.

5. **Calibrate data collection and analysis** to the specificities of a diverse workforce. A constant feed of data could be used to periodically evaluate the impact of OSH monitoring systems on certain groups of workers and highlight gaps that could be filled by taking new OSH actions.

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[26] Khakurel, J., Melkas, H., & Porras, J. (2018). Tapping into the wearable device revolution in the work environment: A systematic review. *Information Technology & People, 31*(3), 791-818. https://doi.org/10.1108/ITP-03-2017-0076