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A digital transformation into occupational health and safety systems: a review of the best practices in Europe

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Abstract. Digitization is actively spreading and widely implemented in the occupational health and safety (OHS) systems. Progressive technologies make it possible to effectively implement digitalised systems in all the elements of management cycle - from planning to monitoring, evaluation and solutions in the different economy sectors.
Aim. The purpose of the article is to give a review on the current state of digital transformation in OHS policy of European countries and Ukraine and identify the positive and negative aspects of digitization in OHS management systems.
Method. The review is based on full research articles, reports and conference proceedings in Scopus, Web of Science and Google Scholar database, where the keywords 'digitization', 'occupational health', 'safety', 'robots' and 'management systems' for literature search have used.
Results. In total 51 sources were under analysis, including 23 full research articles and 28 publications from EU-OSHA, ILO and OECD. The database formation and use of big data systems and control tools for monitoring and assessing work environment, digital guidelines, legislation and e-teaching platforms are the main digital instruments in OHS management systems. Use of workplace navigator programs helps to collect necessary information and make right regulations by the law. Use of new digital technologies allows more effectively perform OHS inspection, service and risk prevention functions, and diminish work related injuries and illnesses.
Conclusions. A new ideology of public policy in developing digitalised OHS management systems (DOHSS) will make the evidence-based solutions effective and achieve high safety standards and stimulate business growth of specific industries on the national and EU level. The best European experiences of digital transformation into OHS management systems can be implemented also in Ukraine.

Key words: digitisation, occupational health, public policy, safety management.

INTRODUCTION

Digitization is the 'use of digital technologies to change a business model and provide new revenue and value-producing opportunities' (Gartner Glossary, 2023). Digitization is a key trend to change contemporary work environment more safe and comfortable, using digital OHS management systems through technology innovation in different economy sectors. New digital systems in agriculture, named as twin digital systems, observed as the next generation of digitization, supporting farmers by continuous and real-time monitoring of physical environment (farm, field) and updating the state of virtual world applications. It includes data recording, modeling and artificial intelligence, big data, and different wireless technologies for simulation, analysis, prediction, and communication (Nasirahmadi & Hensel, 2022).

Digital strategy is the development of new business models, implementing new technologies, creating new mindset, and teaching new working skills. It's a challenge to redesign management strategies and operating models, and develop the capabilities to transform successfully new knowledge into work environment and production (Xebia Digital Strategy, 2023).

Biosystems engineering (BSE) is a discipline that integrates engineering science with applied biological, environmental, and agricultural fields (Briassoulis et al., 2014), that includes also new technology aspects and OHS management systems in different economy sectors.

Currently, the issue of BSE management stability is being updated all over the world, taking into account an increased economic, migration, political and epidemiological risks. One of the tools in this direction is to consider digital transformation, concerning all spheres of modern societies, including public policy and development of OHS management systems. In the progress of new and multi-risk environments which concerns rapid implementation of new technologies, the OHS management needs are continuously changing, focusing on the new, non-trivial solutions for better safety of workers. First of all, it is a good opportunity to develop new OHS management systems at the intersectoral level with help of different digital tools. Analysis of 'big data' for customers, employers and employees, 'smart solutions' in the course of labour protection methods, mobile applications for monitoring of navigation and contacts of persons, personal 'smart devices', cyber-physical technologies, infrastructure of 'smart cities' and other digital solutions can help in this matter. There are many new developments in this context in the EU countries. But in the context of new technological risks these changes require the accelerated digital transformation into OHS management systems.

Many researchers are devoted to the topics of digitization and stress the need for training on modern technologies for better prevention and management of occupational risks and give the opportunity to consider and understand in depth a number of issues on this agenda. Takala and co-workers were focused on using of virtual workplace safety observatory programme to systematize OHS knowledge based on Singapore model, the Observatory for Workplace Landscape (OWL) at the level of public administration and policy, which was successfully implemented into practice (Takala et al., 2013).

New digital solutions can help to improve safety and diminish work related health complaints among workers with the high risk jobs. The farmers thereat more often use the agricultural machines with digital programs to prevent serious health problems

among farmers - to operate the machines autonomously or remotely reduce the human exposure to pesticides (Abdukakhhorovich, 2022).

To achieve a better safety culture at the work places the vital media communication was used for reaching large number of stakeholders, workers and informal sector (migrant workers, vulnerable groups) (Takala, 2005). The new and emerging risks have been identified and established through research agenda setting priorities for evidence for policy and practice, concentrating on the global analysis of occupational accident data (Takala 2005; Takala et al., 2013). The researchers in UK and Ireland have studied psychosocial risks at work through analysis and modeling, using representative datasets and computer processing programs, getting useful information for problem-based solutions (Jain et al., 2022).

The research team (Colosio et al., 2017) analyzed the results of workers' health surveillance (WHS) for early diagnostics of work-related diseases (WRD) in accordance with EU legislation (article 14) in all EU-28 countries. The modern network has used to send the questions to the selected experts of the International Commission on OHS. Additionally, the study reports and research articles on WRD statistics, cost-benefit analyses and evaluation programs used to measure costs of health outcomes caused by occupational risks among employees. The study results revealed that harmonization of the context of WHS is needed in the European Union (EU) countries. It was reported, that in some countries WHS was provided to all workers by the law, independently from their exposure to occupational risk factors, gender or vulnerability, but in other countries only selected subgroups of workers had an access to WHS. Hence, the systematic electronic surveys make it possible to come up with legislative proposals for the entire EU region to improve safety situation of workers. Digitization of monitoring process of working conditions significantly optimizes OHS management systems.

Different digital technologies are developed in EU countries to improve OHS management systems through EU legislations and achieve effective safety training programmes for employees and employers (Niskanen & Lehtelä, 2015; Güner & Ekmekei, 2019). In Ukraine, many specialists, practitioners and scientists are interested in digitization of different economy sectors as medicine and other service areas and also in production, and have made efforts to popularize this knowledge (Gromyko, 2020; Україна-2030E, 2020).

Ukrainian and Estonian researchers, in the context of digitization of management processes, comprehensively study the impact of stress as occupational risk factor in production by digital monitoring and tracking the main vital signs of personnel (Järvis & Tint, 2008; Prokopenko et al., 2021). Based on digital technologies and statistical analysis of big data, the researchers have algorithmically developed the structural and functional models of providing medical care to the population (Demikhov et al., 2022) and analyzed healthcare system development toward European integration (Prokopenko et al., 2018), and developed digital algorithms for assessing the risks of occupational diseases, based on complex factors analysis at the municipal and national levels (Demikhov et al., 2022). Also, Ukrainian researchers comprehensively study and offer computer-based solutions to the problems caused by health risks of workers due to Russian aggression (Kolesnyk et al., 2022).

Digitization is the most important 'tool' for improvement of OHS research on safe work environment to better manage new and emerging risks. The digitization studies have focused mainly on creation of complex data bases on the national and European

level (for example eSTAT or Eurostat). When using big data analysis and digital control tools for monitoring and evaluation of working environment, we can see the better functions of communication, information and consultation, documentation and reporting obligations, and thorough incident investigation in practice (Eurostat, 2023; Statistics Estonia's e-service, 2023).

In particular, the authors of the publications have studied the impact of IT technologies on development of OHS management, substantiating the need for use of digital communications, considered the features of the formation of a digital culture in the field of OHS management. Along with this, the features of the introduction of personalized electronic tools in the field of OHS, and their impact on management and policy in this area, have not yet been adequately disclosed in recent scientific publications. Although digital transformation reduces risks at work, as shown above, there are some obstacles on cultural and structural levels, including limited personal cost for the training to use of big data analysis and digital control tools for monitoring and assessing work environment (Ward, 2022).

The aim of the article is to give a review on the current state of digital transformation in OHS policy of European countries and Ukraine, and to identify the positive and negative aspects of digitization in OHS management systems.

MATERIALS AND METHODS

The search of full research articles, reports and conference proceedings in Scopus, Web of Science and Google Scholar programmes were used. In literature search the keywords 'digitization', 'occupational health', 'safety', 'robots' and 'management systems' were inserted. Also, we focused on the developmental programmes, survey results and legislative acts published in web-pages of EU-OSHA (European Agency for Occupational Health and Safety), ESENER-3 (European Survey of Enterprises on New and Emerging Risks), ILO (International Labor Organisation) and OECD (Organisation for Economic Co-operation and Development). The sources of this information considered eligible if they were published after 2000 (up to May 2023). In the Appendix 1. four examples of digitalised systems have added, which were produced through the research projects or startup programmes and implemented in OHS management practice.

RESULTS AND DISCUSSION

The main focus point in this review is to describe, how new technologies through digitization can help to improve safety at the workplaces and lower physical and mental load and prevent occupational injuries and diseases among employees of different economic sectors in EU countries, including Ukraine. Through the description of different digitization systems in OHS management systems the authors bring out the general classification of digital solutions and also, the strengths and gaps of digital management systems.

In total 51 sources have used in this review, from which 23 full research articles describing research results of digitization transformation in OHS management systems. Also, the sources of EU-OSHA, ILO and OECD, reporting the developments in implementation of digitization, have used. The ESENER-3 survey results on digitization

were under discussion. A number of web-platform information has been used to bring the examples of digital solutions in practice.

In EU countries, a lot of attention has paid to the digitization in the field of OHS area. The third European Survey of Enterprises on New and Emerging Risks (ESENER-3, 2019) covered over 45,000 establishments across all business size classes and activity sectors in 33 European countries. It showed that different digital technologies have been implemented at the workplaces - personal computers (PC) 85% and laptops 77% used at the workplaces. About ten percent of enterprises used machines with PC monitoring of worker's performance or determining the content or peace of work and few workplaces used smart wearable devices and robots that interact with workers. Only 6% of enterprises have reported that the digital technologies are not in use (Fig. 1) (EU-OSHA, 2019).

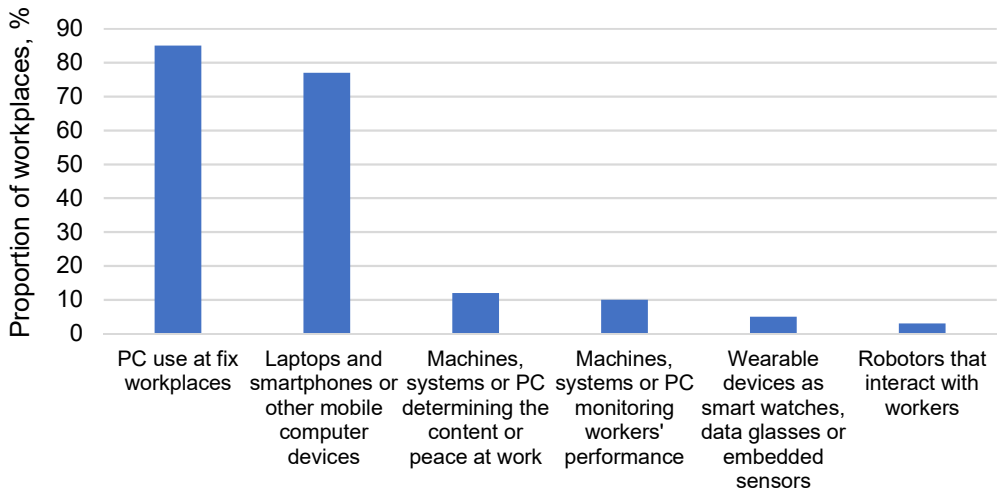

Figure 1. The workplaces with different digital technologies in EU countries (ESENER-3, 2019; EU-OSHA, 2019).

Although the modest use of smart devices and robots at the workplaces was reported in the 3rd EU survey, sharp increase is predicted due to fast development of technologies in the last years. However, EU-OSHA strategy support the development of digital skills among workers, public services and all infrastructures in European economy. The action plan for implementation of digital programs for 2030 must be achieved in EU through multi-country projects: 1) to increase computer skills (form 54% to 80%), 2) to cover gigabit internet services for 100%, and achieve fast data access and processing, 3) to improve digital transformation into services (cloud computing services, big data, artificial intelligence could cover 75%), and 4) providing access for everyone to eID, electronic health records & online public (European Union, 2023).

Some examples on digital transformation into the OHS practice have been shown below. In the last years the European Occupational Safety and Health Agency (EU-OSHA) has developed Online Interactive Risk Assessment (OiRA) tool, a web-based platform that allows to create risk assessment (RA) in any small size enterprise in standardized way for all the economic sectors. The platform is developed

and maintained based on the Dutch risk assessment tool RI&E *(De risico-inventarisatie en -evaluatie)*. However, RA use in practice could be quite challenging, especially for micro and small enterprises (MSEs), who due to lack of resources or poor OHS knowledge may carry out it unsuccessfully. However, implementation of OiRA tool in MSEs is an excellent initiative at the EU level to assess workplace risks. This e-tool is multilanguage example for use among employers and employees in different sectors of the member states. OiRA is open through online platform for all partner countries and available in interactive website (EU-OSHA, 2023).

The Chinese researchers (Wang & Wang, 2023) are working on the regional development of digitization of OHS management systems. Here the digital economy and technology can facilitate a shift in corporate management approaches, such as the provision of professional digital occupational health counseling, training and medical services, or directly affect workers by improving awareness on personal health risks and reducing work related injuries and illnesses. The development of digital solutions in the industries has been shown to improve the efficiency of regional public and occupational health services. The development of the digital economy can significantly improve the efficiency of technical knowledge and technical support for low-skilled employees. In the regional digitization process the improvement of economic structure and OHS management systems through policy practice in industrial and technological development is very important. The government needs to focus on two processes: 1) to enlarge the coverage of broadband network and digital infrastructure, promote digital technology and the application of digital economy in the field of OHS, and provide different digital OHS management services; 2) development of digital OHS intervention policies through regional differences, where the local governments need to formulate more detailed goals of digital economy development in different regions.

Discussing the Ukrainian experience of digitization in sphere of public health, we can describe the case of prevention of tuberculosis in the country. The fact is that currently in Ukraine there is a wide spread of tuberculosis, which directly affects workers health and is closely related to OHS programs. Thus, use of digital technologies to protect workers health through the national tuberculosis (TB) control programs has already been implemented in Public Health of Ukraine. It is an electronic scoring and early warning system designed to improve the procurement, ordering, and supply planning processes for tuberculosis treatment, created by the USAID Program to Improve Access to Pharmaceuticals and Services (SIAPS). It is an electronic tool that turns complex calculations and forecasts of national TB control programs into easy-to-display graphs that showcase key information for drug management among the patients (Demikhov & Dehtyarova, 2020).

Also, there is a need to modernize education in the field of OHS in Ukraine. As a positive example, we can consider the experience of digitization of studies in medicine at Sumy State University, Ukraine. The university has created an online learning ecosystem for medical students. The electronic platforms OCW (Open Course Ware), LecturED (elements of online learning ecosystem) and virtual classes with help of electronic problem-based learning (PBL) and testing of students have been developed. Based on the digitized pre-graduate studies the future doctors can effectively use virtual programmes for diagnostics and treatment of patients. These innovative learning approaches have proven to be effective. The use of information and telecommunication technologies and problem-based learning is important in formation of competitive

competence among postgraduate medical students on master and doctoral levels in the Sumy State University (Demikhova et al., 2016). Similar technologies in OHS education have been implemented as well, capacitating readily measure and create virtual workplaces.

According to the International Energy Agency (IEA) report, in order to meet Net Zero scenario, the global stock of flexible assets must increase tenfold by 2030, which means that all the sources have to be supported by smarter and more digital electrical grids (OECD/IEA, 2017). The adoption of digital technologies, such as smart meters and distributed monitoring and control devices, is necessary to fully exploit the potential for flexibility in the growing number of connected devices. Thus, in global perspective, in 2010–2021 about 9 billion digital automated devices were used worldwide, including 1 billion smart meters (Fig. 2). The sensors and IoT (Internet of Things) technologies have shown the sharpest increase in the last decade. The agency's analysis point-out, that significant growth in adoption of these technologies is necessary, and which can be further accelerated through policy and regulatory frameworks.

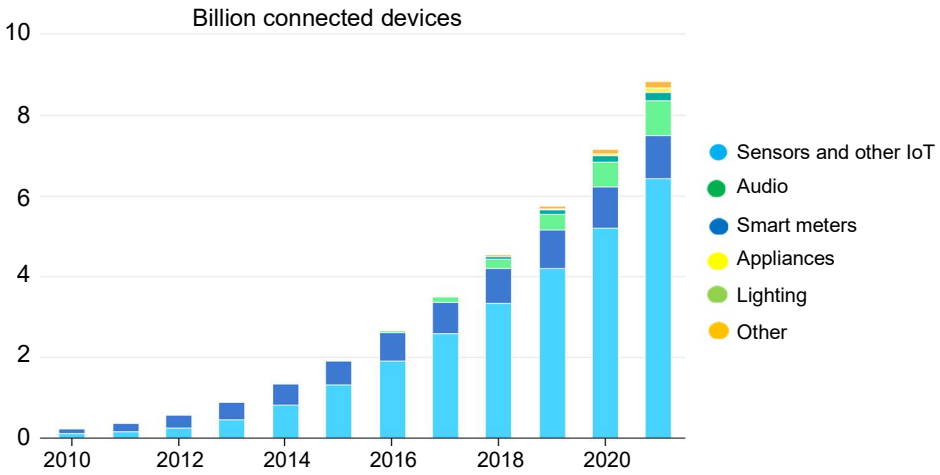

Figure 2. Global stock of digital automation devices (billions) 2010–2021 (OECD/IEA, 2017).

In the context of the digital transformation of biosystems, the topic of living laboratories is also relevant. The concept of 'living laboratories' involves the use of innovative tools in form of an open ecosystem (ENoLL). Such laboratories offer safe space for the development, testing and validation of innovative products. These are kind of test benches for innovative solutions, systems and products, and these booths have platform function for cooperation. For example, an interesting experience of using the Digital Healthy Lifestyle Laboratory was presented in the UK. The specialists from the University of Brighton tested digital equipment for screening the health of elderly people in a nursing home. The researchers used special connectors adapted for digital internet television, sensors for measurement internal comfort parameters in the living quarters, using tools with hand controls for users, smart glasses and wrist trackers of vital activity. Also, the researchers conducted periodic workshops together with elderly people in all

stages of the study. They introduced to the stakeholders, how an open innovation ecosystem can work effectively and how to modernize digital health technologies. Thus, in interaction with the stakeholders on the platform of living laboratories was resulted in solutions for simplifying processes and introducing benefits (Fotis et al., 2022).

Also, within the framework of the EU project 'Horizon 2020' the implementation of living laboratories 'AgriLink' into practice was used and with the purpose to stimulate the transition of sustainable development using electronic toolbox as digitalised platform for analysis of risk factors among workers in agriculture (AgriLink, 2020). Interesting was the idea of the AGR-278 precision farming research group from the University of Seville and the University of Cordoba in developing of activities in three areas:

– working out the estimates of spatial variability of agricultural lands;
– using robotic systems for chemical and physical means of effective weed control;
– reducing the risks of mycotoxin contamination of food products through the introduction of 'smart farming' technologies (Ottonomy.io, 2023).

In addition, researchers from Denmark (Karlsen et al., 2022) analyzed the European health and safety smartphone application market, useful in practice for safety professionals and ordinary workers. These applications comprised of information on OHS laws, standards, work environment regulations, monitoring and evaluation. We can find the applications of guidelines for working with toxic substances and different ergonomic measurements, OHS training programs and even stress release exercises and gymnastics for prevention of occupational diseases. There are the mobile applications for documenting industrial accidents, reporting and prevention. All the above-named smartphone applications can be used as the tools to personalize OHS activities of workers with specific jobs or high-risk occupations, similar to the concept as 'personal medicine'. Additionally, the ecosystem of OHS management was created, in which the mobile application acts as an electronic device for personal measurement of occupational risks and screen for preventive measures and treatment of symptoms caused by work. Thus, a personalized occupational health system is developed, which is linked to digital programs of general medicine and public health. Here we can talk about the creation of non-standard and individual solutions in the field of OHS for different groups of workers. This develops an individual scope of OHS practices, where smartphone applications are functioning as connecting bridges between the employee and various services around him/her (medicine, occupational and public health, insurance system, pharmacologists, psychologists etc.). Moreover, in order to achieve the desired effect, such mobile applications can be linked to the government platforms and legal databases on the national and EU levels as a whole. Thus, the information in the mobile applications will be constantly updated. There is feasible to develop a workplace navigator program to collect and make available through the internet all the necessary information on OHS management in the context of specific industries, positions and types of work.

Mobile applications, websites of statistics and legal databases as well as workplace navigators can be integrated into the single electronic system. By the analogy with telemedicine, in this way the direction of smart-Occupational Health was developed (Fig. 3).

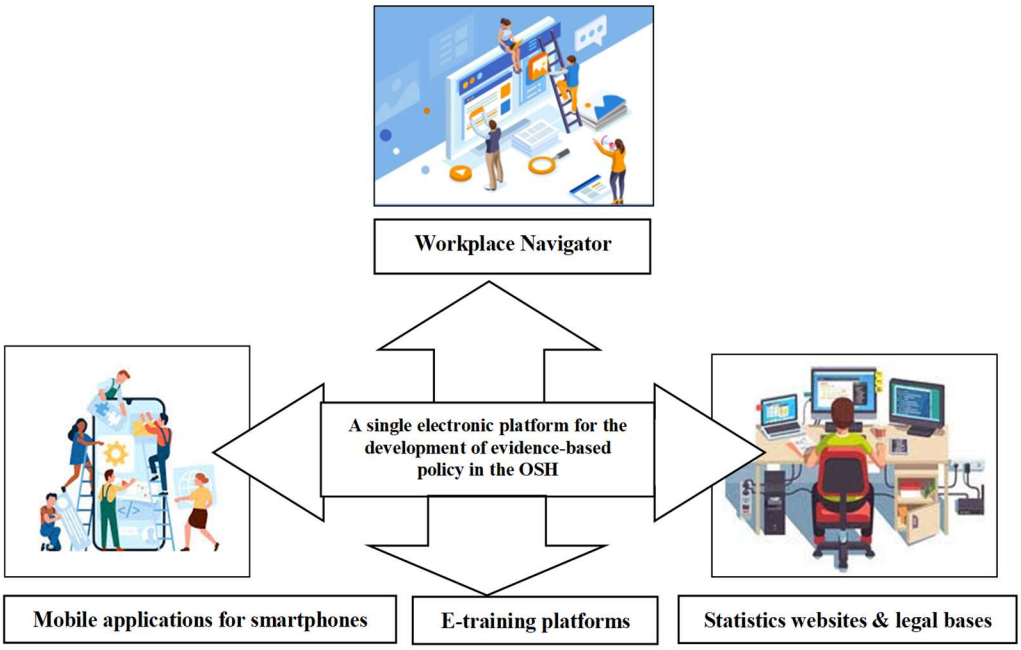

Figure 3. Unified electronic system smart-Occupational Health (EU-OSHA, 2019; Birner et al., 2020; Fotis et al., 2022; Karlsen et al., 2022; McFadden et al., 2022).

The final results of unified electronic system smart-Occupational Health allow collecting, storing and analyzing of various information, translating it into effective practical management decisions. Still, the generalized practical knowledge, statistics and regulatory information are used in the workplace navigators and in simplified configurations of smartphone mobile applications. The classification of implemented digital systems in OHS management practice is shown in the Table 1.

On the other side, smartphones and navigators can be used to provide feedback to websites - receive and accumulate the primary data. Such electronic systems can be used to train personnel and carry out OHS management decisions in the enterprise. Increased access to information is one of the biggest benefits of digital OHS training process, that allows automatic testing of knowledges. The access to digital tools (online training materials, videos, interactive simulations) makes it easier to gain deeper understanding of complex safety topics. Digital learning also encourages collaboration between trainees, experts and students. In the e-classes the students can make group networking, exchange information and discuss on course materials or ask the questions from the lecturers. This helps to provide personalized feedback from supervisor to their trained personnel in real time.

The complex digitalized OHS data systems are necessary for the evidence-based managerial solutions and implementation of an effective policy and strategy in the field of OHS. The electronic access to OHS information helps to build up safe work environments and prevent work related accidents and illnesses.

The researchers have paid more attention on the govermental role of digitization in OHS policy. The goverments could focus on OHS developments and digitization as the ‘brokers’ and facilitators of data sharing and digitally-enabled innovations across the

sectors. This new function of governments could imply a range of public investments and policies on data gathering, advisory services, and safety standards for broad technological diffusion. The governments should take into account difficult-to-measure aspects of technologies, considering quality of life improvements (for example reduced family labor) or barriers in adoption of new technologies (human capital requirements or mistrust in 'black-box' technologies) (Rose et al., 2021; McFadden et al., 2022).

However, knowledge about the quality and impacts of different digital applications and advisory services has seen as public goods. In agriculture digital needs have integrated into the curricula of education and training programs and important target group for skills development consists of various computer specialists (Birner et al., 2020; McFadden et al., 2022).

Digitization in OHS management systems has become widely used in agriculture: drones, satellite GPS, computer programs for logistics and econometric calculations, sensors on storage tanks of finished products and robotic systems in crop and animal production. The farmers are increasingly relying on software for data analysis and transform the results into meaningful insights. The digital tools are useful when deciding on whether, in which amounts and when to use crop protection products, pesticides or biopesticides. Using robots on the fields or in greenhouses is helping to prevent long time exposure on awkward postures and repetitive movements causing musculoskeletal complaints (low back, shoulder and hand-wrist pain) among plant workers (Advanced Mobile Group, 2022a). In sheep farming the digital control system is in use - GPS drone with sensors can detect animals' location in the landscape - it's diminishing farmers' physical load and mental stress through better animals' control and safety system (Advanced Mobile Group, 2022b; Birner et al., 2020) (See Appendix 1. Example 1 and 2).

In transportation the innovative next-generation vehicles and technologies improve driving safety and prevent traffic accidents. The example, a sleep monitoring device was developed through startup program of the University of Padua and the Sleep Medicine Center of Negrar. This analyzer is able to detect the driver's brain activity and falling asleep in a timely manner, alerting the user wake up just with slight vibration. The system control driving safety among the workers, who are exposed to driving long distances and often in night time (Granz, 2022) (See appendix 1, example 3).

The Californian startup Ottonomy has built the autonomous robot for the jobs in indoor environments with aim to diminish physical loads among service workers. The robot can deliver food and beverages, groceries, and packages for last-mile deliveries or indoor environments - this technology is important in lightening loads among workers (Ottonomy.io, 2023) (See appendix 1, example 4).

The classification of digital instruments in the field of OHS management, based on the best EU practices is shown in the Table 1.

In the Table 1, when summarizing the classification above, it has been described 6 groups of digital instruments in OHS management systems: e-training platforms and software, big data systems, tools for monitoring work environment, electronic health surveillance and advisory service, and electronic legislation and safety guidelines. All the digital solutions support the implementation of new technologies into production and different service sectors, improving work safety and preventing of work accidents and illnesses among employees.

Table 1. The classification of digital instruments in OHS management systems (developed by the authors)

Name of the digital instrument for OHS management	Description of using a digital tool in OHS practice	The implementation of results into practice
E-training programmes OHS		
Electronic training platforms in the field of OHS: OCW, SSU, MIX, LecturED, virtual classroom, virtual workplace. Webinars and e-training software are widely used in EU countries to improve safety knowledge among OHS specialists, politicians, employees and employees	Digitization of occupational health and safety education based on problem-based learning (PBL) (Demikhova et al., 2016). The use of incident and audit management software (Wolters Kluver, 2023). The Occupational Safety Card training that improves the chances to get a job in Finland. (Occupational Safety Card Webinars, 2023) [https://a-	Implemented and applied in the educational process of Sumy State University, Ukraine. The root cause analysis helps to identify the fundamental causes of problems in the enterprise. The Occupational Safety Card (OSC) training provides basic information about risks in work environment and occupational health and safety in workplaces. A personal OSC is valid for 5 years, and granted to the persons who complete the 7 hours training
Big data systems		
Smart meters, distributed monitoring and control devices.	Electronic tools of the 'NetZero' scenario until 2030 (Fig. 2) (OECD/IEA,2017). Robotic planting, the digital control systems in crop and animal production, interactive next-generation vehicles and technologies and autonomous robots for service jobs in the indoor environment (See Appendix 1, Examples 1-4)	Implementing now in OHS management systems of EU countries. The start-up projects, research institutions and university researchers have developed autonomic robots for different physical work tasks to prevent mental and physical overload
Computer program 'SIAPS' for optimization of management decisions	USAID Access to Medicine Services; Access to Electronic Assessment and Early Warning System to Optimize TB Treatment (Demikhov & Dehtyarova, 2020).	The program is operating as an electronic tool in the management system at the Ministry of Health of Ukraine
Various databases and BigData analysis systems	Regional collection and analysis of Big Data on accidents and injuries at the workplace (Colosio et al., 2017; Güner & Ekmekei, 2019; Ward, 2022; Eurostat, 2023; Wang & Wang, 2023).	OSH data analysis has widely used for reporting and making political decisions in the EU countries and advisable to apply in Ukraine as good EU experience

Table 1 (continued)

Tools for monitoring work and living environment		
Innovative tools in the form of an open ecosystem (ENoLL): digital Internet television, sensors for the comfort of the atmosphere in residential premises, smart glasses, wrist life trackers	The concept of 'Living Labs' (test benches) (Fotis et al., 2022)	Digital Healthy Lifestyle Lab (UK) uses digital equipment to screen people's health in the nursing homes
Workplace monitoring software	Workplace Landscape Observatory (OWL) programme (Takala, 2005)	Implemented into OHS management practice by Singaporean researchers
AgriLink Living Laboratories	EU Horizon 2020 Project (AgriLink, 2020)	Used to analyze occupational risk factors in agriculture for workers
Small Business Occupational Health and Safety Online Risk Assessment Tool 'OiRA'	The OiRa tool is helping owners and management of small enterprises in resource-limited conditions to calculate their own risks in the field of occupational health and safety with the help of unified computer programs (EU-OSHA, 2023)	The OiRA program is based on the Dutch RI&E and it has been implemented in the EU-OSHA online platform
Electronic workers' health surveillance and advisory service		
Mobile applications and smartapp systems	May contain information and instructions for the user about: preventive exercise in the workplace, ergonomic measurements, etc. (Karlsen et al., 2022)	Such devices for personal measurements of repetitive movements are widely in use in different EU countries. It is a tool for personalization of labor risk measurements
The global navigation satellite systems (GNSS) and information used in apps.	Workplace Navigator (Birner et al., 2020; McFadden et al., 2022)	Use of different digital applications and advisory services are is important in OHS management in farms.
'Smart-Occupational Health' software programmes Smart Clinic: Occupational health and wellbeing for your business. Occupational health and wellbeing services in UK	On-line OH service for workers' health surveillance: a smart online booking system, referral process, and virtual feedback via webcam or smartphone using the android and IOS 'apps' - access to OH services any time and place	Use of e-questionnaires for pre-testing of health complaints of employees and OH advisory service. Examples: CBT - on-line cognitive behavioral therapy program for testing and virtual training of employees (consists of 8 sessions, with 3–5 modules); OHS support for schools to prevent work stress among teachers (Smart Clinic, 2023a; Smart Clinic, 2023b)

Table 1 (continued)

Electronic legislative materials and safety guidelines		
ILO conventions EU directives National legislation	OSH Act and related legislative acts on work environment and exposure limits of risk factors	Audit Matrix for the ILO Guidelines on OHS Management Systems to help governments and enterprises to improve OSH performance (ILO-OSH, 2013). Implementation of directive 89/391/EEC in Europe to improve workers' health surveillance system. Occupational Health and Safety Act (OSH Act) based on which work environment legislation has put into practice (OSH Act, 1999/2023).

Remarks: SSU – Sumy State University; MIX, OCW (OpenCourseWare), LecturED – elements of Sumy State University's online learning ecosystem; SLAPS - Systems for Improved Access to Pharmaceutical and Services; ENoll – European Network of Living Labs; USAID – United States Agency for International Development; TB – tuberculosis.

Still digitization challenges and positive and negative consequences are under discussion. The positive outcomes are shown: 1) the access to electronic standards and legislation improve safety, 2) use of big data can improve transparency of production and helps to make right decisions, 3) the digitization in industrial world attracts young people and motivate them to find skilled jobs, 4) the digitization in economy can drive productivity - reducing labor costs and input costs, 5) digital solutions reduce the amount of dangerous work, improving wellbeing of workers (Rose et al., 2021). The common barriers of digital transformation include high costs of maintenance of new technologies, user friendliness, high operator skills' requirements, worker mistrust of algorithms, technological risks and all other unknown risks for today (McFadden et al., 2022; Prokopenko et al., 2022). The main negative sides of digitized OSH management in agriculture are cyber security weakness and lack of robots with emotions make it difficult to trust them (Rose et al., 2021; McFadden et al., 2022).

The ESENER-3 survey (2019) referred to the potential negative health impact of new technologies - rise of psychosocial risks (information overload, conflict between work and private life and fear of job loss ect) among employees. About 2/3 of respondents in this survey mentioned the need for more flexible working schedules when using devices (smart watches, data glasses or other embedded sensors). The negative health impact of digitization were most often under discussion in administrative and service sectors (34%), education (33%), health and social service sectors (33%). By the countries this topic was most often focus point in Hungary (58%), Romania (42%) and the United Kingdom (37%). The survey stressed an urgent need for continuous training on risks related to work with robots or ohter digitized tools in the workplaces (EU-OSHA, 2019).

For instance, when discussing the issue of Ukraine, due to a large-scale war unleashed by Russia is currently continuing on its territory and anthropogenic influence of man on the surrounding nature is increasing, especially with a military component. Today Ukraine is one of the most mined territories in the world and working population under pressure of severe stress, turning into various psychological and mental problems. Therefore, when planning the post-war period of restoration of economy in Ukraine, it is also necessary to take into account the OHS problems and psychological rehabilitation programmes of the population affected by military influence. The digitization of recovery processes of safety and economy here is very important. However, there are some obstacles in the process of digitization in the field of OHS in Ukraine:

– insufficient national funding leads to poor coverage with computer equipment and programs;
– insufficient number of IT-specialists in this area;
– conflict of interest for business owners, who wish to increase profits and reduce OHS costs, whereas their financial risks widely associated with workers' compensation of work accidents. At the same time, the digitization of OHS management will lead to greater transparency of the employers' actions and their accountability to labour inspectors. These factors do not encourage employers to implement digital solutions;
– there is a dilemma in political decision-making: how to find a balance between the policy of stimulating the growth of investment into business and the policy of protecting health and life of workers directly involved in this business? Increasing digital control may deter potential investors. Also, strict national legislation, together with the process of total digitization in this area, can worsen the investment climate in the particular country. Thus, the question of finding a balance at the level of public policy between fiscalization and liberalization of OHS area still remains unresolved.

After all, when regarding to staff perception of using digital tools in work environment, there are lot of questions of the safety and security of business. The research results of Yassaee & Mettler (2019) stress vulnerability and attitude of employees towards privacy when using digitalised personal data systems which diminish their willigness to adapt them into practice. Hereafter, from side of the designers and users, there are four key affordances for digital solutions: 1) to make visible users' OHS behavior and quarantee security of personal health information, 2) to motivate employees to engage in healthy behavior, 3) to inform workers about potential health risks or emergency situations in work environment, and 4) to guarantee users control over their personal data (Yassae & Metler, 2019). So, further recommendations and new reforms are needed in the EU countries to introduce digitization, human resource analytics and risks of artificial intelligence (AI) at the workplace (Ahlers, 2016; EU-OSHA, 2019; Sysoyeva et al., 2021).

EU-OSHA strategy 2025 support the involvement of workers in the implementation of any digitalisation strategies and development of an ethical framework for digitalisation and codes of conduction. A strong 'prevention through design' approach and good collaboration between academics, employers, social partners and governments in research and innovation of digital technologies regarding the human aspects are the same important points of view. EU strategy supports the advanced workplace risk assessment, using the applications of digitalisation, considering the possible impacts in terms of OSH challenges. A use of regulatory framework to clarify OSH liabilities and responsibilities in relation to new systems and ways of working is important in OSH

strategy. Implementation of an adapted education system and training for workers and provision of effective OSH services for all the digital workers are the main key points of EU safety strategy (EU-OSHA, 2018).

CONCLUSIONS

There is a rapid increase of digital transformation in OHS management systems. The synergistic potential of social, mobile, cloud technologies, as well as technologies for analysing big data and IT systems, together can lead to positive changes in these areas. It should be noted that for all EU countries, including Ukraine, it is necessary to introduce fiscal control measures in the field of OHS management and offer the best digital solutions through new technology development. It is important for designers, IT-specialists and users to follow personal data safety and company security rules. It's important to build up the systematic e-training programmes on safe use of new digital programmes and analyse new and emerging risks in work environment.

Based on literature analysis we classified the results of digitization transformation into OHS management system in five sub-areas: e-training tools, big data systems, tools for monitoring work environment, electronic workers' health surveillance systems, e-safety guidelines and legislation. Workplace navigator systems help to collect all the necessary information on OHS in the context of specific industries, positions and types of work. Mobile applications, smart devices, digital statistical and legal databases as well as workplace navigators can be integrated into a single and secure smart-Professional Health electronic system. A new ideology of public policy is formulated for developing successful DOHSS and transition it into a polycentric system, making effective managerial decisions, based on the evidence-based information.

The important role here are playing the governments in building relationships according to the OHS model 'employer-employee-labour safety inspector-work environment' and based on the principles of mutual understanding, trust, respect, self-development, self-preservation and reputational responsibility. Certainly, use of new digital technologies allows more effectively perform OHS inspection, offer service and risk prevention functions, and diminish work related injuries and illnesses.

The topic of a digital transformation into OHS management systems can be developed and implemented also in Ukraine, using the best European experience in this area. There is no need for immediate penal and punitive measures. At first, during the first years, it is necessary to focus on auditing and explaining to all partners their rights and obligations, as well as introduce the main OHS principles to prevent occupational injuries and diseases and violations of legal requirements. Thus, the digital OHS management is the important part of regional policy to stimulate business growth and to achieve high safety standards in Europe.

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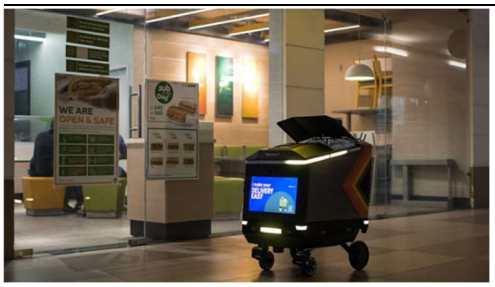
APPENDIX 1

 **Example 1.** Robotic planting in greenhouse.	Using robots in planting work helps to prevent long time exposure of awkward postures and repetitive movements causing musculoskeletal complaints (low back, shoulders and hand-wrist pain) among plant workers (Advanced Mobile Group, 2022a).
 **Example 2.** GPS drone search for sheeps with sensors in the landscape or forests.	The digital control system to diminish farmers' working hours and physical load and work stress due to better animals' safety system (Advanced Mobile Group, 2022b, Birner et al., 2020).
 **Example 3.** Innovative next-generation vehicles and technologies.	A system that improve driving safety among truck and bus drivers exposed to risk of sleeping when driving long distances and often in night time to prevent traffic accidents (drivers, including drivers) more. The device is able to analyze the driver's brain activity to detect falling asleep in a timely manner and alert the user wake up just with a slight vibration (Granz, 2022).
 **Example 4.** Autonomous robots for the service job in indoor environments.	Californian startup Ottonomy has built the autonomous robot for the job to diminish physical loads of service workers. It can deliver food and beverages, groceries, and packages for last-mile deliveries, or indoor environments. A DOHSS purpose to lighting physical load of service workers (Ottonomy.io, 2023).