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ARTIFICIAL INTELLIGENCE AND OCCUPATIONAL MEDICINE: CHALLENGES, OPPORTUNITIES AND THE ROAD AHEAD

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SUMMARY: Artificial intelligence is fundamentally reshaping occupational medicine through applications in automation, smart monitoring, extended reality training, algorithmic management, and digital work arrangements. The EASOM Summer School 2025 examined how AI technologies enhance occupational health systems by enabling real-time risk identification, predictive surveillance, and targeted interventions to prevent work-related accidents and diseases. Practical applications include smart personal protective equipment, wearable sensors, augmented reality training systems, and predictive diagnostics exemplified by noise-related hearing loss risk assessment. However, significant challenges accompany these opportunities: data quality concerns, new technological hazards, psychosocial risks including surveillance-related stress and work intensification, algorithmic bias, and accountability gaps. Implementation requires comprehensive governance frameworks emphasizing early worker involvement, privacy-by-design approaches, phased pilot programs, and human-centered practices that complement rather than replace traditional occupational safety measures. Professional responsibility and education demand new competencies in digital literacy, algorithmic critical thinking, and applied ethics while maintaining essential clinical judgment and empathy. AI offers unprecedented potential for protecting workers' health and safety when responsibly implemented within transparent frameworks, but poor management risks deepening inequalities and eroding established protections. Successful integration depends on multidisciplinary research, international cooperation, stakeholder engagement, and a commitment to human-centered occupational medicine that prioritizes worker dignity and wellbeing.

Key words: *artificial iIntelligence, occupational health, medical education*

INTRODUCTION

The EASOM Summer School 2025, held online under the theme "Artificial Intelligence and Occupational Medicine: New Technologies and Future Perspectives", brought together experts from diverse disciplines, countries, and generations to reflect on a technology that is already reshaping the practice of occupational health and safety. The two-day program brought together international experts to explore how AI is transforming clinical practice, risk assessment, education, and workplace safety management. The opportunities are substantial. Artificial intelligence is defined as machine-based systems that infer from inputs to generate outputs — including predictions, decisions, and content — with varying degrees of autonomy and adaptiveness, influencing both physical and virtual environments and

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many aspects of clinical care pathways in occupational medicine *(Topol, 2019)*. The technology highlights multi-stakeholder use of AI to prevent work-related accidents and diseases and to enhance health promotion initiatives, with potential to replace some human tasks while augmenting clinical and preventive work

Artificial Intelligence (AI) can enhance the efficiency and quality of occupational health systems, reduce administrative burdens, broaden training methods, and enable real-time monitoring of workers' health and workplace environments. Its applications range from risk prevention and equipment failure prediction to diagnostic support and innovative educational programs. When responsibly implemented, these tools foster safer and healthier workplaces, prevent accidents and occupational diseases, and strengthen occupational health systems.

This article constitutes a summer school report — a recognized form of scientific publication in medical and health journals whose purpose is to document, synthesize, and disseminate the scientific discourse of a structured educational event. It differs fundamentally from an original research article in that it does not generate new empirical data; rather, it provides a curated and contextualized account of expert presentations and discussions. The report is based on presentations, panel discussions, and expert exchanges delivered during the two-day programme of the EASOM Summer School 2025. Contributions have been grouped by thematic area to facilitate reading and to reflect the breadth of the scientific programme.

This report is organised into the following thematic sections: 1. AI in workplace automation, robotics, and smart monitoring; 2. smart personal protective equipment and wearable technologies; 3. AI in occupational risk assessment; 4. psychosocial and ethical risks; 5. AI in occupational medicine education and training; 6. AI in research, scientific writing, and information literacy; and 7. governance and regulatory frameworks. A synthesis and conclusions follow.

AI IN WORKPLACE AUTOMATION, ROBOTICS AND SMART MONITORING

Automation and advanced robotics remove workers from "3D jobs" (dirty, dangerous, and dull occupations), support heavy or repetitive tasks, and reduce physical strain through exoskeletons and assistive systems, thereby lowering exposure risks and musculoskeletal loading when properly selected and deployed. Smart occupational safety and health tools integrate environmental sensors, wearables, and AI analytics for real-time alerts, exposure profiling, and evaluation of preventive measures, enabling evidence-based interventions addressing chemical, physical, biological, and ergonomic risks *(EU-OSHA, 2018)*. Extended and virtual reality technologies strengthen training for complex and high-risk scenarios, support remote operations, and aid in pre-task hazard identification in hard-to-reach or hazardous locations. Algorithmic management can optimize scheduling, support skills development, and detect inappropriate behaviors, with potential benefits if designed for worker support rather than control. Digitalized work arrangements including telework and platform work may improve flexibility and workplace inclusion while requiring management of ergonomic, psychosocial, and organizational risks inherent in hybrid work routines *(ILO, 2021)*.

Sensor ecosystems expand temporal awareness for health surveillance and exposure monitoring, enabling earlier and more targeted interventions based on continuous data collection and analysis. Communication systems, insight generation platforms, and modeling frameworks serve as practical bridges connecting data collection to actionable interventions in both clinical and workplace settings. Illustrative AI capabilities presented at the Summer School include digital twins for modeling organizational dynamics and occupational health scenarios, simulated communities for intervention testing, and AI-created virtual reality environments to enhance spatial awareness and training for hazardous tasks.

AI is imperceptibly rewiring clinical and administrative workflows, necessitating vigilance to maintain human autonomy, clarify responsibility versus autonomous machine decision-making, and ensure that interventions follow from monitoring rather than surveillance becoming an end in itself. The argument favours bottom-up, incremental implementation approaches in communities and organizations rather than top-down rollouts, enabling adaptation of AI to local risks, organizational culture, and available resources.

SMART PERSONAL PROTECTIVE EQUIPMENT AND WEARABLE TECHNOLOGIES

The foundation of modern AI applications in occupational health rests on smart digital systems that collect and analyze data to identify and assess risks, prevent or minimize harm, and promote worker safety and health. These systems encompass a broad technological spectrum including sensors, smart personal protective equipment, wearable devices, software platforms, and analytics dashboards. European Survey of New and Emerging Risks (ESENER) data reveal extensive workplace digitalization, with only 4% of establishments using none of the listed technologies *(EU-OSHA, 2025)*. However, adoption of sophisticated systems such as wearable sensors remained relatively limited in 2019, with approximately 4.8% of workplaces utilizing these technologies, primarily concentrated in larger organizations.

Smart digital systems operate in two fundamental modes. Proactive systems provide real-time risk identification, individualized biofeedback, remote assessments, and predictive insights to improve occupational safety and health before incidents occur. They enable improved compliance through automated verification of personal protective equipment use, faster and more accurate decision-making via real-time parameters and predictive algorithms, and targeted training through virtual and augmented reality technologies. Reactive systems, in contrast, focus on locating workers, emergency response, accident investigation, and corrective measures after adverse events have occurred. Modern trends increasingly emphasize proactive approaches that can prevent harm before it manifests.

Several concrete applications were presented during the Summer School. Hand-Arm Vibration Syndrome (HAVS) monitoring systems link tool-specific vibration profiles with wrist-worn exposure sensors to warn workers when approaching exposure thresholds, enabling GDPR-compliant reporting and feedback to equipment manufacturers. Connected multi-gas detection systems integrate static and wearable sensors with cloud-based dashboards to provide real-time alarms, device status monitoring, and compliance tracking, offering enhanced protection for workers in hazardous environments. Augmented reality smart glasses support remote audits and investigations with fewer personnel required on-site. Posture monitoring wearables combine sensor technology, video analytics, and dashboard systems to provide biofeedback and task-level prevention interventions.

Despite their potential benefits, smart digital systems introduce several categories of risk. Data quality represents a fundamental concern, as information can be inaccurate, difficult to interpret, or repurposed away from prevention aims. New hazards include device malfunctions, cyberattacks, or overreliance that displaces collective safety controls. Psychosocial stressors may arise from continuous monitoring, frequent alarms, monotonous tasks, or inadequate training *(Eurofound, EU-OSHA, 2014)*.

Implementation principles must address these risks through comprehensive governance frameworks. Key principles include early and ongoing worker involvement, clearly defined purpose, integration with existing infrastructure and occupational safety and health frameworks, and close cooperation with manufacturers to tailor systems to specific workplace needs. Privacy-by-design approaches centre on anonymization, data minimization, regulatory compliance, and cybersecurity, with role-restricted access where non-anonymized data are clinically necessary. Privacy and ethical considerations are central to AI implementation, requiring strict governance of data collection, access, and use to prevent repurposing and to maintain worker trust and legal compliance *(Ienca, Vayena, 2020)*.

A recent systematic review identified 52 publications spanning 1997 to 2024 on AI in occu-

pational safety and health, with significant growth after 2016 but limited high-quality evaluative studies. This evidence base suggests that recommending widespread workplace AI implementation may be premature without stronger validation in real-world settings. AI possesses a distinctive decision-making architecture in which it selects predictions and generative AI selects words, with value derived from how these selections are constrained by purpose, data quality, and context of use within clinical and workplace systems *(Char et al., 2018)*. The emphasis must be on decision quality, workflow integration, and clarity about when and how AI should trigger protective actions, not merely provide surveillance capabilities.

AI IN OCCUPATIONAL RISK ASSESSMENT

AI can support early diagnosis and disease prevention, exemplified by noise-related hearing loss risk assessment systems that provide continuous exposure monitoring and predictive surveillance to identify workers at elevated risk and guide targeted follow-up evaluations and control measures *(Obermeyer, Emanuel, 2016)*. Potential applications extend to diagnostics, fitness-for-work assessments, return-to-work planning, compensation analysis, worker training programs, and research initiatives, aligning with emerging concepts of "precision occupational medicine" when implemented with appropriate ethical and security safeguards *(Pesapane et al., 2018)*.

Practical applications of AI in risk assessment were demonstrated through several case studies presented during the Summer School. One presentation highlighted AI's role in occupational risk assessment, discussing benefits such as real-time monitoring, predictive analytics, and cost savings, while addressing challenges including data privacy concerns, algorithmic bias, and integration issues with existing systems. AI enables real-time hazard identification, data-driven risk assessment, and optimization of safety measures through continuous analysis.

A particularly compelling application involved workplace violence against healthcare workers. Research conducted in Sicily examined violence against healthcare staff, finding high levels of unreported incidents particularly among nurses and younger personnel. An AI-based prediction system for assessing aggression risks in healthcare environments was presented, demonstrating the potential for proactive intervention strategies that could protect healthcare workers from violent incidents. This application illustrates how AI can identify patterns and risk factors that might not be apparent through traditional risk assessment methods, enabling targeted preventive measures before violent events occur.

Another practical demonstration involved implementing a GPT model for text recognition tasks in occupational safety, showing how AI can assist in processing safety data sheets. However, accuracy levels of approximately 84% still require human validation, emphasizing that current AI technology is sufficient for supporting large-scale data processing tasks but insufficient for fully autonomous operation without human supervision and verification.

PSYCHOSOCIAL AND ETHICAL RISKS OF AI IN THE WORKPLACE

The risks of AI implementation in the workplace are equally significant as its opportunities. Human–robot interaction, poorly designed devices, or technological failures can introduce new physical and ergonomic hazards. Psychosocial risks are of particular concern: work intensification, stress, invasive surveillance, and loss of autonomy. Algorithmic management may lead to dehumanisation and the "datafication" of work, undermining dignity and the sense of belonging. Ethical and legal dilemmas also persist, including algorithmic bias, opacity and lack of explainability, gaps in accountability, and the precarisation of employment *(Mehrabi et al., 2021)*. To these we must add the considerable environmental footprint of large-scale digital infrastructures.

A central issue discussed was professional responsibility. The ambiguity surrounding liability for AI-assisted decisions, combined with the disparity between the speed of technological innovation and the slower evolution of regulation, compels us to rethink the role of professionals *(Schulte, Va-*

inio, 2010). What is needed is a form of "prospective responsibility": not only applying technology but also anticipating its risks, critically supervising its outcomes, and recognizing its limitations.

AI is also transforming the skillset required of occupational health professionals, who must increasingly validate — and, when necessary, reject — the recommendations generated by intelligent systems. This demands new competencies in digital literacy, data science, algorithmic critical thinking, and applied ethics. At the same time, essential human qualities — empathy, compassion, and professional judgment — must remain at the heart of occupational medicine.

AI IN OCCUPATIONAL MEDICINE EDUCATION AND TRAINING

The EASOM Summer School 2025 extensively examined how AI is transforming medical education and continuing professional development in occupational medicine. Presentations emphasized the shift from teacher-centered to student-centered learning approaches. Learning design was conceptualized as creating effective learning environments rather than merely delivering content, with introduction of the flipped classroom model as an innovative teaching strategy. The importance of clear learning outcomes, diverse learning activities, and comprehensive assessments in course design was emphasized *(Ellaway et al., 2014)*.

Practical demonstrations showed how AI tools can rapidly create educational content, transforming textbook chapters into online courses with podcasts, video presentations, and quizzes in under 20 minutes. The demonstrations focused on using platforms including Google Classroom, Notebook LM, Google Forms with GPT-4 extension, and YouTube to create interactive learning materials. Participants raised concerns about AI's impact on education and intellectual property, noting that while AI tools facilitate content creation, they also raise questions about fair compensation for educators' work and potential impacts on educational quality. The consensus emphasized that AI should be used as a tool to support teaching rather than replace human educators, maintaining the critical role of educational expertise and pedagogical judgment.

The importance of education in adopting AI technologies was further emphasized, along with the need for connectivity between different diagnostic devices to enable comprehensive occupational health monitoring. Demonstrations included AI applications in medical education through virtual patient simulations and real-time feedback systems, showcasing practical solutions for addressing modern educational challenges while maintaining clinical competence and professional judgment.

Specialized applications of AI in occupational medicine were explored through presentations on ophthalmology and telemedicine, highlighting AI's potential in diagnosing and managing eye-related occupational health issues. Various AI tools and their applications were discussed, including computer vision systems for assessing workplace eye strain, virtual training programs for industrial workers, and early detection systems for chronic diseases such as diabetic retinopathy and glaucoma that may affect workers' fitness for duty. A European project integrating digital health tools into clinical reasoning education was presented, illustrating collaborative approaches to developing AI literacy and competence among healthcare professionals.

AI IN RESEARCH, SCIENTIFIC WRITING, AND INFORMATION LITERACY

A critical component of AI integration in occupational medicine involves developing information literacy skills and critical evaluation capabilities among practitioners and researchers. Presentations focused on utilizing artificial intelligence in research, scientific writing, and information literacy. Experts presented on how AI tools can assist researchers in conducting literature searches and analyzing data, while emphasizing the importance of critical evaluation and ethical use of AI technologies. The need for researchers to choose appropriate databases, construct effective search queries, and disclose AI use in their work was highlighted.

Sessions addressed AI's potential for generating false references and the importance of information literacy in making informed medical decisions. The importance of fact-checking and citing sources was emphasized throughout these sessions. Practical examples of using databases such as PubMed and Google Scholar were provided, highlighting the complexity of crafting effective search queries that balance sensitivity and specificity.

One particularly instructive case involved an article about AI-generated medical research being rejected due to lack of patient consent and undisclosed AI usage, highlighting the critical importance of ethical transparency in AI applications in medical research and the need for compliance with regulatory requirements regarding patient consent and methodology disclosure. This example underscores the necessity of AI use disclosure as a standard component of scientific reporting.

Comprehensive overviews of data science and artificial intelligence emphasized their applications in healthcare and occupational medicine contexts. Various AI concepts were discussed, including machine learning and deep learning, with examples of their use in medical diagnostics and occupational health monitoring. The growing importance of explainable AI in building trust in AI models was addressed as a critical factor in clinical acceptance and adoption. Presentations on AI evolution highlighted the shift from keyword-based to semantic search engines and AI's potential in personalized medicine approaches.

GOVERNANCE AND REGULATORY FRAMEWORKS

Governance was identified as a decisive factor in the responsible integration of AI in occupational medicine. The European AI Act *(European Commission, 2021)*, the GDPR (Regulation (EU) 2016/679, 2016), occupational safety and health directives, and the proposed revision of the ICOH Code of Ethics *(ICOH, 2014)* are important steps, but they remain insufficient in the face of the pace of technological development. What is required are dynamic and adaptive regulatory frameworks capable of keeping pace with technological innovation while safeguarding health, safety, and workers' rights.

Implementation recommendations from the Summer School emphasized prioritizing risk reduction at source and collective controls, using AI tools to complement rather than replace foundational occupational safety and health measures and clinical judgment. Building transparent, worker-involved governance structures with privacy-by-design approaches, clear purpose limitations, and role-based access controls is essential to protect worker dignity and enable technology adoption with trust and confidence.

Phased pilot programs with measurable outcomes and bias auditing protocols are recommended, ensuring interoperability between systems and maintaining clinical oversight for surveillance activities, diagnostic support, and return-to-work decisions. Transparent use and a clear distinction between performance management and occupational safety and health monitoring are essential to maintain trust and worker engagement. Smart systems should complement rather than replace collective safety measures and established occupational health processes within the hierarchy of controls, while legislation and labor inspection frameworks evolve to ensure effective and accountable integration.

Effective implementation means achieving transparent system use, demonstrating measurable safety improvements, and closing the surveillance-intervention gap so that monitoring signals consistently produce protective actions in real workplace settings. The emphasis must remain on AI as a support tool for timely, high-quality occupational health decisions rather than a substitute for essential clinical judgment and professional expertise.

CONCLUSION

The EASOM Summer School 2025 provided a comprehensive examination of artificial intelligence applications in occupational medicine, demonstrating both transformative potential and significant implementation challenges. AI technologies offer unprecedented opportunities for enhancing worker protection through proactive

monitoring, predictive analytics, and personalized interventions. At the same time, the risks — psychosocial harms, algorithmic bias, accountability gaps, and governance deficits — are equally significant and require deliberate, structured management. Successful implementation demands careful attention to ethical considerations, data privacy protection, worker participation, and the maintenance of human-centered approaches that complement rather than replace traditional occupational safety and health measures.

Future directions must emphasize evidence-based validation, transparent governance frameworks, comprehensive stakeholder engagement, and educational initiatives that prepare occupational medicine professionals for AI-enhanced practice while maintaining core competencies in clinical reasoning, ethical decision-making, and worker advocacy.

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UMJETNA INTELIGENCIJA I MEDICINA RADA: IZAZOVI, PRILIKE I PUT PRED NAMA

SAŽETAK: Ljetna škola EASOM 2025 istraživala je kako tehnologije umjetne inteligencije poboljšavaju sustave zaštite na radu. Primjerice, pomoću identifikacije rizika u realnom vremenu, prediktivnog nadzora i ciljane intervencije, u cilju spriječavanja ozljeda na radu, profesionalnih bolesti i bolesti u vezi s radom. Umjetna inteligencije se već koristi u zaštiti na radu, a primjeri su pametna osobna zaštitna oprema, nosivi senzori, sustavi treninga proširene stvarnosti i prediktivna dijagnostika. Međutim, te mogućnosti prate i neki izazovi, kao što su zabrinutost vezana uz kvalitetu podataka, nove tehnološke opasnosti, psihosocijalni rizike koji uključuju stres od nadzora i veći intenzitet rada, pristranost algoritama te nedostatak odgovornosti. Primjena umjetne inteligencije ne bi trebala zamijeniti tradicionalne mjere zaštite na radu. Naprotiv, to bi trebala biti dva pristupa koji se nadopunjuju, s važnim fokusom na očuvanje privatnosti i rad prilagođen radniku. Profesionalna odgovornost i edukacija zahtijevaju nove kompetencije u digitalnoj pismenosti, kritičkom razmišljanju o algoritmima i primijenjenoj etici, a važno je očuvati vlastitu kliničku prosudbu i empatiju. Umjetna inteligencija nudi potencijal za zaštitu zdravlja i sigurnosti radnika kada se odgovorno primijeni unutar transparentnih okvira, ali loša primjena može imati za rizik produbljivanje nejednakosti i eroziju uspostavljenih zaštita.

Ključne riječi: *umjetna inteligencija, medicina rada, medicinska edukacija*

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