Artificial Intelligence and Occupational Health and Safety, Benefits and Drawbacks

Mohamed El-Helaly [1,2*]

[1]Occupational and Environmental Medicine, Faculty of Medicine, Mansoura University, Mansoura City, Egypt
[2]Faculty of Medicine, New Mansoura University, New Mansoura City, Egypt

SUMMARY

This paper discusses the impact of artificial intelligence (AI) on occupational health and safety. Although the integration of AI into the field of occupational health and safety is still in its early stages, it has numerous applications in the workplace. Some of these applications offer numerous benefits for the health and safety of workers, such as continuous monitoring of workers' health and safety and the workplace environment through wearable devices and sensors. However, AI might have negative impacts in the workplace, such as ethical worries and data privacy concerns. To maximize the benefits and minimize the drawbacks of AI in the workplace, certain measures should be applied, such as training for both employers and employees and setting policies and guidelines regulating the integration of AI in the workplace.

1. Introduction

In 1955, John McCarthy was the first to create the term 'Artificial Intelligence' (AI) [1]. AI refers to the simulation of human intelligence in machines that are programmed to think and learn like humans. It involves the development of algorithms and computational models that enable machines to perform tasks traditionally requiring human intelligence. These tasks include problem-solving, speech recognition, decision-making, visual perception, language translation, and more [2].

AI can be divided into two primary categories: Internet of Things (IoT) optimized for specific tasks and performs well in voice assistants, recommendation algorithms, and image recognition systems [1, 2] and generative AI, i.e., systems that associate words, learn, and solve complicated issues but, despite their name, are not as intelligent as human beings [2, 3].

AI comprises several subfields, such as robotics, computer vision, natural language processing, machine learning, and expert systems. AI mostly relies on machine learning, which uses algorithms to allow computers to learn from experience, providing "intelligent" outcomes without explicit programming [4].

On the other hand, occupational health and safety (OHS) is defined as a multidisciplinary field concerned with safeguarding and promoting the well-being of individuals in the workplace. It encompasses a systematic approach to identifying, assessing, and mitigating risks and hazards that may arise from work-related activities [5]. The primary goals of OHS are to prevent injuries, illnesses, and fatalities among workers and to create and maintain a work environment fostering the workers' physical, mental, and social health [6].

Currently, AI enables real-time monitoring of workplace hazards, identifying and addressing risks

proactively, and enhancing preventive measures through predictive analytics powered by AI forecasts health trends [4, 7, 8]. The incorporation of AI not only improves safety protocols but also advances a comprehensive approach to employee well-being, marking a paradigm shift in the field of OHS with increased efficiency and precision [9, 10]. On the other side, innovative uses of AI in the workplace provide significant challenges for OHS professionals who need to gain a deeper grasp of AI approaches and their possible consequences on work and workers when AI-enabled apps are implemented in the workplace [2, 3, 11, 12]. As AI technologies are used in the workplace, it is imperative to maximize their potential benefits for OHS while minimizing any potential drawbacks.

2. BENEFITS AND APPLICATIONS OF AI IN OCCUPATIONAL HEALTH AND SAFETY

2.1. Worker's Health Monitoring Through Wearable Devices, Sensors and IoT Devices

Wearable devices and sensors in the workplace are pivotal in enhancing workers' well-being, safety, and overall productivity [13]. These devices are commonly used to monitor various health metrics, including vital signs, steps taken, and sleep patterns, identify fatigue or stress levels, and promptly notify workers and supervisors in case of emergencies or potential health risks [13-15]. IoT refers to the network of interconnected physical devices, objects, and systems that communicate and share data through the Internet [16]. In a workplace context, IoT involves embedding various sensors and other smart devices into the infrastructure to collect and exchange data [17]. Numerous studies have indicated that companies can utilize data from wearable devices, sensors, and IoT, enhanced by AI, to identify potential health risks such as elevated stress levels or irregular sleep patterns [14, 15, 18-20]. Moreover, the data collected by wearable devices and IoT can be manipulated by AI to inform the implementation of targeted wellness programs, including personalized fitness plans and stress management workshops, to support overall employee well-being [15, 21]. In hazardous work environments like construction, mining, and manufacturing, specialized wearable devices such as smart helmets equipped with sensors can detect harmful gases, monitor environmental conditions, and assess head injuries [22]. These wearables, integrated with AI, trigger automatic alerts or emergency responses in case of accidents, ensuring timely assistance and preventing severe consequences [23]. Hence, the integration of wearables, sensors, and artificial intelligence empowers both employers and employees to prioritize health and safety, resulting in increased productivity, reduced absenteeism, and enhanced job satisfaction [3, 7]. As these technologies advance, we can anticipate even more sophisticated applications that will reshape the landscape of workplace health monitoring in the future.

Sensor technology extends beyond wearables to workplace health monitoring, with environmental sensors throughout workspaces detecting factors like temperature, humidity, noise levels, and air quality [24, 25]. When coupled with AI-driven systems, these sensors evaluate overall workplace health and safety, identifying potential hazards and proactively improving conditions [22, 26].

2.2. Smart Building Systems for Energy Efficiency and Employee Comfort

AI can optimize smart building systems to enhance energy efficiency while maintaining optimal conditions for employee comfort [27]. This includes intelligent climate control, lighting, and resource management in the workplace [26, 28].

2.3. Hazard Identification and Risk Assessment

Hazard detection programs help protect against various risks, such as unsafe working conditions, workers without protective clothing, misuse of tools and equipment, trip and fall hazards, unattended vehicles, equipment out of place, and other compliance issues [29-31]. Industries can employ AI systems to examine images and videos from workplaces, uncovering potential hazards that may elude human observation [29, 32]. For example, the UK's Health and Safety Executive developed an artificial intelligence program called Estimation and

Assessment of Substance Exposure (EASE) to assess occupational exposure to certain substances in the workplace [32]. Additionally, AI can play a role in forecasting machinery breakdowns. Through the analysis of sensor data on machines, AI can identify abnormal patterns that signal a potential fault [1]. This proactive detection enables companies to perform maintenance before a machine malfunctions, averting potential accidents. Moreover, AI programs can identify, assess, and mitigate risks by analyzing data and identifying patterns and anomalies [16, 32]. However, few studies have been conducted to demonstrate the positive and negative aspects of integrating AI into the risk assessment process and health surveillance in workplaces. This might be because the integration of AI in the industry is still in its early stages, and the main current focus is on its impact on immediate concerns such as safety and regulatory compliance [4, 10, 29].

2.4. AI-Integrated Smart Personal Protective Equipment

Personal Protective Equipment (PPE), such as respirators, safety shoes, ear muffs, and safety goggles, has always played a crucial role in safeguarding workers from various hazards in the workplace [33]. When a task poses inherent risks that cannot be sufficiently controlled through collective technical or organizational measures, the use of PPE becomes essential to enable workers to perform their tasks with reduced injury risks [5]. The reliability and effectiveness of PPE are paramount, aligning with the established principle of the hierarchy of prevention.

Smart PPE refers to PPE that combines traditional PPE (such as firefighter protective suit) with electronics, such as sensors, detectors, data transfer modules, batteries, cables, and other elements [22, 34]. By combining AI technologies with smart PPE, it actively monitors and adapts to changing environmental conditions, detecting hazards, assessing air quality, and providing real-time alerts [22, 34, 35]. This innovation enhances communication and fosters a proactive approach to occupational safety, ensuring a safer work environment across diverse industries.

2.5. Workplace Violence Monitoring

Workplace violence is a pervasive issue globally that poses a risk to workers' mental health. More than one in five people (almost 23 %) in employment have experienced violence and harassment at work, whether physical, psychological or sexual [36]. AI can play an important role in preventing workplace violence. Natural language processing (NLP) is a technique from computer science that helps to analyze large bodies of text. Using NLP, AI can scan emails and files for inappropriate language, alerting managers when such phrases are detected [37, 38]. With voice recognition, AI can recognize spoken phrases in meetings, generating detailed reports to address instances of harassment [36, 39, 40].

2.6. AI in Drug and Alcohol Screening Programs

About 60% of people with substance use disorders (SUDs) are currently employed [41]. Hence, workers' alcohol and drug use can harmfully impact both the workers and the workplace, resulting in absenteeism, high turnover, decreased productivity, and other safety problems [42]. AI can contribute to more efficient and accurate drug and alcohol screening processes in the workplace [43]. Automated systems can analyze biological samples, ensuring compliance with safety regulations and promoting a substance-free work environment [43, 44].

2.7. Workforce Mental Health Monitoring

AI-driven tools are increasingly employed for monitoring and addressing mental health issues in the workplace, which can be done using remote health monitoring systems by tracking vital signs and health metrics and providing real-time information to healthcare professionals for early detection of health issues among workers [4, 45]. In addition, NLP can play a role in analyzing workers' communication for signs of stress, enabling timely interventions and support [38]. This enables organizations to implement preventive measures to support workers' mental health and well-being.

In their literature review, Moshawrab et al., 2022, discussed the importance of using AI-integrated

smart wearable devices to screen and identify occupational physical fatigue among workers [13]. They reported that AI-integrated smart wearables have established their usefulness in identifying and screening fatigue at work, which can limit the harmful effects of fatigue on workers [13].

2.8. Musculoskeletal System and Ergonomics

The work-related musculoskeletal disorders (WMSDs) are considered an important cause of occupational injury at the workplace, leading to increased absence rates from work [46, 47]. On the other hand, ergonomics can defined as adjusting work environments, tools, and worker postures to prevent WMSDs induced by ergonomic risk factors such as awkward posture, repetitive movements, and excessive force at work [48, 49]. Ergonomists usually assess each worker's ergonomic risk factors using techniques such as postural analysis, anthropometric measures, motion and time studies, biomechanical models, force evaluation, and energy expenditure assessments [48, 50]. Recently, several studies have shown the possibility of improving ergonomic analysis through the combined use of artificial intelligence and wearable sensors [26, 51-53]. AI-assisted health programs can analyze ergonomic factors and individual anthropometric data to predict and prevent musculoskeletal disorders in the workplace [51]. AI-driven wearable devices can continuously analyze workers' motions and body postures [52] to recognize movements that may pose a risk of injury. Alerts are then issued to workers to mitigate the potential for long-term health problems [53].

2.9. Automating Dangerous Tasks Using AI Automated Bots

Bots, short for robots, are automated software programs designed to perform specific tasks. The most important bots used in industry are collaborative robots (Cobots) and Chatbots. Collaborative robots, often referred to as cobots, are designed to work in close proximity to humans, fostering a collaborative and cooperative environment [54, 55]. Unlike traditional industrial robots that operate in isolation or behind safety barriers, cobots are engineered

to share the workspace with human operators [3]. This collaboration aims to enhance productivity and safety in sectors such as manufacturing and logistics [3]. Chatbots are bots designed to engage in conversation with users, and they are commonly used in customer service, providing quick and automated responses to queries [55]. Automation through AI and Machine Learning (ML) enhances the efficiency of robots, particularly in handling hazardous tasks, including safety inspection of hazardous environments, maintenance, and handling of dangerous materials [55, 56].

2.10. AI-Enhanced Occupational Health Compliance Safety Audits

By using IoT sensors, AI can track and audit every individual worker on multiple levels, ensuring that workplaces adhere to safety standards, minimize legal risks, and promote a culture of compliance [16]. This includes monitoring worker locations, tracking vital signs, alerting workers to environmental hazards, providing accurate information to remote workers, reducing the risk of physical injuries, and enhancing staff training [7, 16, 24].

2.11. Decision Support Systems (DSS)

Decision support systems (DSS) are computer-based tools or systems that support decision-making activities within an organization [57]. They provide interactive access to databases and help users analyze complex data, generate reports, and make decisions based on the insights gained [58]. AI-powered DSS can assist managers and executives in making informed decisions by analyzing complex data sets, identifying patterns, and providing insights and recommendations [3, 7]. These systems leverage techniques like data mining, machine learning, and NLP to aid decision-making across various industries [57, 59].

3. DRAWBACKS AND ETHICAL ISSUES OF AI IN OCCUPATIONAL HEALTH AND SAFETY

Despite AI's immense potential to enhance workplace safety, its implementation brings challenges

and ethical issues. Developing and implementing AI systems can be expensive and may require significant investment in hardware, software, and training [3, 7].

High-quality data is essential for AI to make accurate risk assessments and envisage effective recommendations. If the data used is incomplete, outdated, or inaccurate, it can significantly impact the performance of the AI system, which could result in erroneous predictions and potentially lead to safety hazards [12]. Similar to humans, AI is susceptible to amplify bias if it is trained on biased data. So, it is imperative to ensure that AI systems are trained on balanced and representative data to mitigate such biases [60].

3.1. AI-Related Ethical Issues at the Workplace

Artificial intelligence can potentially revolutionize health and safety practices, introducing ethical considerations that must be addressed. Critical ethical issues include ensuring privacy and data security, given that AI systems rely on extensive datasets containing personal information such as wearable devices and sensors [12, 60, 61]. So, it is essential to guarantee this data's ethical and secure collection, utilization, and storage. Additionally, concerns arise regarding biases and discrimination inherent in AI systems stemming from the data on which they are trained, leading to potential unfair or discriminatory decision-making [4, 12, 62]. Furthermore, the automation capabilities of AI raise apprehensions about job displacement, prompting considerations about the necessity for safety professionals to acquire new skills in response to evolving tasks [12, 63, 64].

3.2. AI-Impacts on Worker's Mental Health

Integrating AI in health and safety could negatively impact workers' mental health, including anxiety and stress related to job automation or the potential for AI errors to lead to accidents [4, 11, 65, 66]. Workers may feel a loss of control in an environment monitored by AI systems, experience isolation and disconnection from human colleagues when interacting more with AI, and perceive a diminishing sense of meaning and purpose when

their tasks are automated by AI [4, 66, 67]. Recognizing and addressing these emotional impacts is essential to creating a positive and supportive work environment while implementing AI technologies. Considering the role of occupational physicians excluded from algorithm definitions and the potential organizational and evaluation implications arising from such exclusion is of utmost importance. This brings attention to the critical intersection between healthcare professionals, technology, and regulatory frameworks, emphasizing the significance of including occupational doctors in discussions around AI implementation and compliance with existing laws and regulations.

4. Conclusion

In conclusion, integrating AI in occupational health and safety offers benefits such as enhanced safety and productivity through predictive maintenance and real-time risk assessment. However, drawbacks include ethical concerns, data privacy considerations, and the need for regulatory compliance. Work organizations must balance innovation with respecting workers' rights, investing in workforce education, building AI expertise, and collaborating with solution providers to seamlessly ensure a safe workplace that integrates AI and human ingenuity.

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