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Predictive Functions of Artificial Intelligence for Risk Assessment in Remote Hybrid Work

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ABSTRACT

Remote hybrid work risk assessment is an obligation for the employer according to Occupational Safety and Health (OSH) regulations. Risk management requires the cooperation of the worker, who is now responsible for recognizing and managing hazards, necessitating specific technical training. Generative Artificial Intelligence (AI) technologies can support the knowledge needs of both workers and employers as effective tools for prevention in occupational health and safety, respecting privacy regulations and avoiding remote control of workers. Researchers from INAIL, Universitas Mercatorum, and the University of Sannio are developing an AI-based assistant for assessing risk in remote and hybrid work, facing challenges in assistant training due to limited availability of data on incidents and illnesses related to remote work. The generative AI prototype will be able to evaluate the relationship between remote work activities and types of injuries, using domestic injury data to identify patterns and high-risk areas. By integrating Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), the hybrid model will enable a dynamic and comprehensive analysis of hazards, contributing to a better understanding of risk factors in hybrid work contexts.

Keywords: Artificial intelligence, Occupational health and safety, Remote hybrid work, Hybrid workplace, Risk perception

INTRODUCTION

The widespread adoption of hybrid work has implications for Occupational Health and Safety (OHS) that have not yet been thoroughly examined. In fact, the literature on this topic is still limited, and the studies thereof exhibit numerous methodological biases (Oakman et al., 2020; Lunde et al., 2022;

Shiri et al., 2022). This is partly due to the accelerated and widespread adoption of hybrid work during the COVID-19 pandemic, extending into sectors that were not previously involved in such working arrangements.

Hybrid work is a complex mode of employment merging on-site and remote work, often facilitated by means of various digital tools. However, this concept extends beyond the variety of environments in which work activities can take place. Indeed, it also involves a transformation in the perception of employment, wherein remote work introduces more flexible organizational forms and characteristics akin to those of self-employment. This transformation has implications for OHS, particularly in the context of risk assessment (Simoncelli et al., 2023).

European legislation mandates to assess risks as a general measure to protect the health and safety of workers in the workplace. However, the legislative framework has not been modified yet to address the evolving nature of workplaces. Despite the significant changes in work patterns, especially due to the COVID-19 pandemic, European and national laws have not been adapted to this revolution yet. Consequently, several employer obligations to ensure the health and safety of workers need more and more reconsideration in order for them to remain updated and effective.

Work environments are a foundational category in occupational safety because they are the places where work processes occur, and they are typically subject to risk assessments by employers who make spaces and tools secure by leveraging protective devices and operational and emergency procedures. In the context of hybrid work, the variability of the environment is not directly controlled by the employer, but by the worker him/herself who must manage a "dynamic" risk (EU-OSHA, 2023).

In such contexts, according to the current regulations, the responsibility for identifying and assessing the risks remains in charge of the employer, but the worker is involved in the risk management as well, for example by means of an active cooperation with the employer in identifying risks closely linked to the chosen work environment.

All aforementioned issues represent some of the most evident challenges in occupational health and safety. Besides the difficulty for employers to forecast all the environments where work may be performed, they have also to be aware that the worker is not a safety technician and lacks an extensive multidisciplinary specialist knowledge, necessary to perceive and understand a complex set of often overlapping risks. On the contrary, traditional workplaces benefit from a safety management system with many experts and enough trained staff, who usually collaborate with the employer to prevent and manage hazards inside a physical and predetermined architecture where work is usually carried out.

In order to properly address these challenges, researchers from the Italian Workers' Compensation Authority (INAIL), a public non-profit entity safeguarding workers against physical injuries and occupational diseases, along with Universitas Mercatorum and the Department of Engineering of the University of Sannio, are collaborating on a project funded by INAIL itself. This project, named SWILSS (Sistema Wearable Intelligent per Lavoro Smart Sicuro in Italian–Intelligent Wearable System for Safe Remote Working in

English) aims to study the dynamicity of the risks in hybrid workplaces as well as innovative tools based on cognitive technologies, particularly generative artificial intelligence, to support knowledge of remote employees and provide continuous and real-time risk assessment.

In the rest of the paper, we discuss the overall scenario of hybrid workplaces and their inherent risks, the activities, related to generative artificial intelligence, to be carried out in the SWILSS project, a comparative analysis within domestic and commuting accidents in the context of INAIL inspection activities, and some concluding remarks.

WORK ENVIRONMENT, PERCEPTION, AND RISK IDENTIFICATION

In the context of hybrid work, the environment wherein the particular working activities are carried out is no longer uniquely identifiable, static, measurable, and analytically assessable, but it becomes a concept with extremely variable boundaries.

In this type of work arrangement, living or relational environments can be chosen for carrying out work tasks. The work environment, in addition to changing on the basis of the choices and needs of the workers themselves, becomes a scenario wherein the employees may share space with others, including not only fellow workers, but also family members, children, or even pets. This results in an overlap of environments and a continuous fluctuation of the correlated risk factors. These encompass both emerging as well as traditional risks contextualized in new environments, taking on different variables. For instance, in a domestic setting, the place where an employee works is often associated with pieces of furniture, such as chairs, tables, sofas, etc., normally designed for personal and non-work-related purposes. Moreover, these pieces of furniture are not usually intended to be used so frequently as those more apt for a proper working purpose.

At the same time, the work activities become structured around goals to be achieved and are no longer confined to a predetermined time frame, getting a variable nature that affects very much risk assessment by making the exposure times to hazards variable as well.

In this light, the employees' training path for safely working needs to be deeply reconsidered, with a focus on fostering an "active participation" in the risk identification process and with a minimum requirement of experience in risk management.

For researchers and all stakeholders of the OHS scenario, understanding employees' risk perception becomes even more crucial. As a matter of fact, risk perception is personal, shaped by individuals' conscious or unconscious evaluations and influenced by factors such as age, gender, emotions, social or organizational culture, collective worker experiences, personal knowledge of the hazards, and continuous or occasional exposure to the risks themselves (Siegrist et al., 2005; Slovic, 1987; Slovic, 2000).

The careful understanding of the level of risk perception among employees can help with a correct risk assessment process and enhance health and safety levels within companies.

Risk assessment in a hybrid work context, in addition to examining specific risks related to the task itself, must necessarily consider a range of generic risks (such as the possibility of increased musculoskeletal disorders related to ergonomics, fire risk, microclimate hazards, etc.) that may arise from the context wherein the activity is carried out and that are subject to changes, e.g., with a frequent relocation of the workplace. Thus, these risks can vary frequently, requiring a continuously updated assessment process. This, in turn, requires a great change in the role of the employee, who becomes responsible for him/herself and must manage his/her own safety, as well as that of those around, who may not always be involved in the work process. Therefore, the employee has to achieve a multi-perspective and multidisciplinary view of the risks, which can certainly be strengthened by the help of AI-based tools.

As a consequence, the role of an AI-based tool can be crucial for collecting and processing data, always respecting the privacy of the workers when appropriately handled. Indeed, the inherent dynamic risk in hybrid work environments could be easily monitored through direct technological surveillance of the worker and the chosen environments, but in this way it could raise concerns regarding the risk of illegitimate employer control over the worker and the guarantee of personal data protection. Therefore, the aid of AI-based tools must adhere to the strict law requirements, making the overall situation even more challenging.

THE SWILSS PROJECT

The SWILSS project, funded by INAIL through the BRIC 2022 call for project proposals, aims at creating a virtual assistant based on a generative artificial intelligence algorithm (more precisely a Large Language Model (LLM) (Touvron et al., 2023; Darveu et al., 2020)) for helping and providing useful suggestions to remote working employees, as well as for an ongoing evaluation of the hybrid workplaces on the part of the workers' supervisors.

The virtual assistant, exploiting a continuous evaluation of the risks, with both peripheral and centralized software modules endowed with state-of-the-art analytics capabilities in order to elaborate domestic injury data as well as demographic variables, will be able to:

- monitor the individual risk of an employee during remote working situations,
- categorize the vulnerability of different workers into possible specific injuries,
- search for temporal patterns to pinpoint potential regularities in the injury events themselves,
- provide suggestions and/or specific alerts or warnings to employees in order to avoid injuries or work-related diseases as well as strategies or solutions to soothe them,
- enhance the base of knowledge about remote working health damages,
- send anonymized reports to the supervisors of the employees.

The aforementioned double perspective (peripheral and global) is essential because often dangerous actions can impact different contexts (spatial and

temporal). Therefore, the global intelligence would have the task, starting from peripherally gathered information, of carrying out complex interaction and root-cause analyses as well as compliance checking to define not only personal, but also global risks.

A crucial aspect of the prototype smart assistant will be its ability to identify high-risk areas in home environments, also considering the social interactions with parents, relatives, or friends as well as non-work-related items and devices. The envisaged smart assistant will identify key factors connected with serious injuries by leveraging advanced classification and regression techniques, delving into the main causes of accidents in remote hybrid working places, be they systemic, cultural, or organizational.

The envisaged prototype will also possibly take advantage of recent advancements in job safety assessment, which entail hybrid approaches that apply both Convolutional Neural Networks (CNNs) (O'Shea et al., 2015) and Recurrent Neural Networks (RNNs) (Rumelhart et al., 1985) for image analysis of remote work environments. These solutions exploit the strong points of both CNNs and RNNs, providing a dynamic and complete evaluation of safety hazards in various workplace settings. Thanks to the integration of CNNs and RNNs, the hybrid approach can test not only individual frames for possible risks, but also a time series of events potentially leading to hazardous situations. This solution could be particularly effective in monitoring activities where the hazard evolves over time, such as the gradual development of unsafe conditions or the progression of workers' fatigue or bad postures.

The virtual assistant could have both a Cloud-based and an Edge-based part and could assume the form of a chatbot, possibly endowed with a proper user-friendly avatar, and it will get as input information in real-time from the employees themselves and from databases about domestic injury events. The virtual assistant will be customizable on the basis of the particular employee and flexible to adapt to the different remote working places. Moreover, it will also be able to provide a minimum of explainability or interpretability of the provided suggestions or reports sent to the employees' supervisors, by leveraging both ante-hoc or post-hoc explainable AI techniques.

The risk assessment on the part of the envisaged virtual assistant will be carried out following the framework proposed by Pishgar et al. (2021), i.e., dividing the risk in three main categories (ideal working status, increased risk but injury not happened yet, taking place of the accident).

In summary, the output of the project will be:

- the software and hardware prototype of the virtual assistant with both the data mining and LLM engine,
- the user interface (mobile and desktop) as well as the informative dashboard for supervisors,
- an enhanced database for remote working accidents to be made available to the research community as well as to practitioners.

The ongoing project is facing a primary challenge: the scarcity of data in the literature and databases from which to draw a validated case history of

accidents and occupational diseases in the hybrid work environment sector. Such data are essential for training the envisioned generative AI-based assistant, designed to evaluate the relationship between work activities performed remotely and the corresponding types of injuries. Some workarounds we are going to try are the registration to EuroSafe on the part of INAIL and a possible collaboration with the Italian National Institute for Health for jointly accessing the European Injury DataBase (EU-IDB).

COMPARATIVE ANALYSIS WITH DOMESTIC AND COMMUTING ACCIDENTS

The need for a useful quantity of data and information to train the envisaged AI-based assistant has led researchers to consider conducting comparative studies about domestic accidents. This involves utilizing European databases focused on collecting accident data, leveraging the expertise of INAIL in Italy. INAIL is the competent authority in Italy for workplace accidents and occupational diseases, and its wealth of information on health and safety at work could be useful as a significant reference for international research. In this regard, it could be possible to compare INAIL data and those coming from other European databases containing standardized transnational information on accidents resulting from domestic incidents and leisure activities, workplace incidents, or traffic incidents. These data could be integrated within the AI-based support tool as useful training knowledge base, with the purpose of obtaining both descriptive statistics and a proper classification of risks, environments, and variables for the risk assessment in hybrid contexts.

Additionally, the research group is starting experimental investigations in sectors that were characterized as hybrid even before the changes amplified by the COVID-19 pandemic. This could involve examining work performance in locations different from the corporate headquarters.

INAIL AND INSPECTION ACTIVITIES

INAIL can rely on a multi-decade knowledge base of workplace realities nationwide, as it is also engaged in certification and verification activities. INAIL technical staff constantly interact with activities outside the workplace, encountering a great variety of work environments and situations. It has been deemed interesting to determine how and to what extent the employees involved are instructed regarding the risks they might be exposed to. This pertains not only to the specificity of the environment they operate in (beyond the risks associated with their own activities), but also to other tasks and interactions with people they may encounter during work.

The landscape of INAIL certification and verification services is multifaceted, allowing engagement with extremely varied realities in terms of business sector, performed activities, and size of the company. Additionally, some certification and verification activities may need to be carried out in domestic contexts, such as periodic checks on LPG tanks installed inside

private houses. This provides an opportunity to approach situations closely related with those typical of remote work scenarios.

In order to gather this information and assess its subsequent applicability in the context of remote work, a questionnaire is usually provided to INAIL technicians aiming to derive information about:

- the type of performed activity,
- the locations where the activity is carried out (specifying its frequency),
- the main risks to which the technician is exposed,
- the received training and pieces of information.

The questionnaire includes a first section requesting data to frame the technician's activity and a section that delves into aspects related to risk perception and, more importantly, how these risk exposure situations can be attributed to the environments in which they operate. This is done to derive scenarios akin to the conditions of remote work.

CONCLUSION

The study of OHS in the context of hybrid and flexible work features significant challenges due to the scarcity of data in the literature and of specific databases. Risk assessment in these work environments involves a shared responsibility between the worker and the employer as well as the variability of work environments, which makes it more challenging for employers to identify hazards and perform subsequent assessments.

One of the most exciting aspects of research in the field of OHS for remote and hybrid workplaces is the potential to fill knowledge gaps for workers and address employers' difficulties through innovative technologies, especially those based on AI. This could support safety management by collecting experiential data to define the new boundaries of dynamic risk. Particularly challenging is the alignment of innovative technological tools with strict legal requirements, especially considering the new European regulation on artificial intelligence (AI ACT).

A collaborative project involving researchers from INAIL, Universitas Mercatorum, and the University of Sannio aims to study the dynamic risk typical of hybrid environments and build a virtual assistant based on generative AI to both enhance the employees' knowledge about hazards and provide employers with data and tools for almost real-time risk assessment.

In this regard, the challenge of obtaining specific data may be overcome through three research directions: mapping hazards, environments, and risk situations derived from data related to domestic and commuting accidents, conducting investigations in sectors characterized by hybrid work, and leveraging international databases.

The use of innovation to support prevention must be planned while respecting regulatory constraints related to the protection of personal data and worker control. This requires a responsible and ethical choice of technologies to ensure their sustainable use.

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