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The Challenge of New Forms of Work, Innovative Technologies, and Aging on Decent Work: Opportunities for Occupational Safety and Health*

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Summary

Occupational safety and health (OSH) can be relevant in achieving the United Nation's Sustainable Development Goal of decent work by 2030. However, further OSH actions are needed. This paper identifies the role of OSH in addressing two of many determinants of decent work: new forms of work/innovative technologies and worker aging. The authors conducted a discursive analysis of the two determinants and provided examples for consideration. New forms of work and innovative technologies can not only promote but also undermine the future of decent work, and unhealthy aging impedes longer working lives. With a focus on the OSH aspects of new jobs, innovative technologies, and aging, decent work is more likely to be achieved.

1. Introduction

The scientific literature has increasingly corroborated the relationship between decent work and occupational safety and health (OSH) [1-6]. However, progress toward achieving the United Nations' Sustainable Development Goal 8 on decent work and economic growth has not been fully realized, and further efforts to identify OSH actions are needed [7]. To this end, we developed a staging framework and conducted a discursive investigational process to expand the focus of OSH toward decent work. The framework is a matrix, with the x-axis containing the four International Labour Organization (ILO) principles of decent work (employment creation, social protection, rights of workers, and social dialogue) and the y-axis addressing eight determinants of decent work [new (innovative) technologies and

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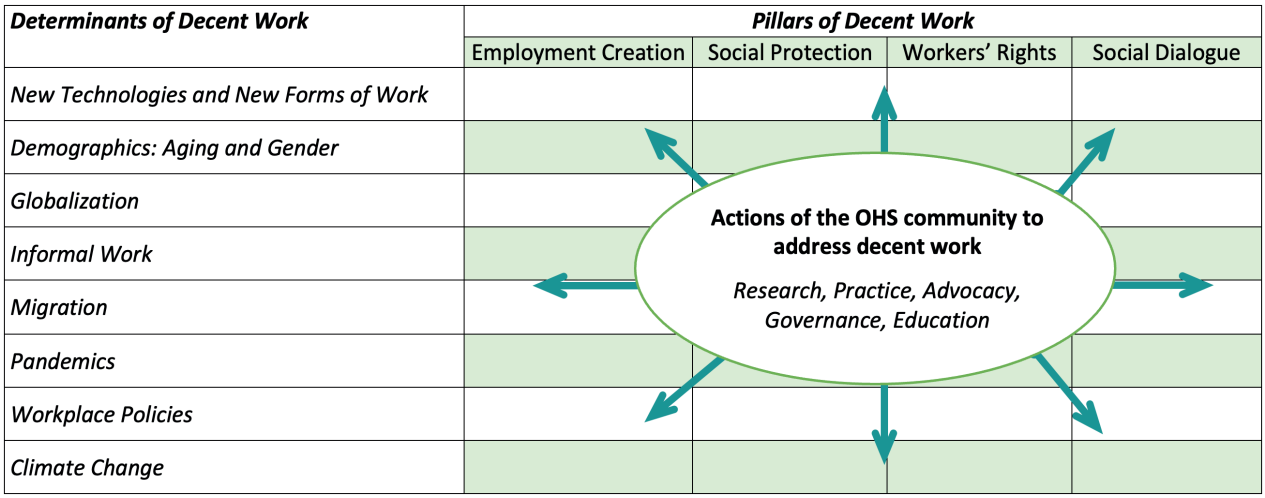

Figure 1. Framework to expand the role of OSH to achieve decent work. Adapted from ref. [4]

new forms of work, demographics (aging and gender), globalization, informal work, migration, pandemics, OSH policies, and climate change] (Figure 1).

To help address the cells in the matrix, we reviewed the impediments and recommendations for achieving decent work in each of the primary function areas of OSH (research, practice, advocacy, governance, and professional education). This paper addresses new forms of work and innovative technologies regarding the pillars of decent work, particularly social protection and workers' rights. We then focus on a demographic determinant—aging—and its relationship to decent work. Aging is a critical determinant of decent work since the world's population is aging [8].

This paper aims to illustrate how two determinants from the framework—*new forms of work and innovative technologies* and *aging*—affect decent work from an OSH perspective. We chose these determinants because they represent our interests as authors and researchers and address the first two rows in the framework. Moreover, they represent significant determinants of decent work. These two determinants reflect changes in work and the workforce—critical aspects of the changing world of work. These changes challenge the OSH field and impact the realization of decent work. Work cannot be decent when workers die or become ill, injured, or disabled. Recent statistics indicate that 2.9 million workers die every year globally from work-related diseases and that 0.32 million of these deaths are due to occupational injuries [9]. Thus, the field needs to know how work and the workforce change and can influence these statistics. This paper is designed to contribute to that awareness.

However, the OSH scientific community needs to turn its attention not only to new technologies and new forms of work and aging but also to other determinants that can impact health and safety in the workplace, such as gender, globalization, migration, climate change, informal work, OSH policies, and pandemics [4]. All these factors also influence the implementation of decent work, defined by the ILO [10] as follows:

> Decent work sums up the aspirations of people in their working lives. It involves opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for all, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men.

OSH is one of the foundational elements of decent work. Aspects of OSH are characteristics of each ILO pillar of decent work. For example, employment creation addresses worker training, unemployment, and underemployment; social protection includes OSH and good working conditions, work hours, and work-life balance; workers' rights underpin OSH and include refusal of unsafe work, safe work standards, and dignity and equality; and social dialogue promotes workers' voices and communication between workers and employers.

To understand the relationship between OSH and decent work, it is helpful to remember that the main objective of OSH is to eliminate adverse effects on workers' health, particularly occupational diseases and accidents at work, following exposure to risks in the workplace. To achieve this objective in daily practice, the OSH system uses among various approaches, a traditional approach that relies on the classic model of occupational risk assessment developed more than 40 years ago by the US National Academy of Sciences [11].

In the last few decades, numerous technological discoveries have also begun impacting the world of work with consequent changes in work processes, which have become more efficient, resulting in new forms of work. Accordingly, OSH needs to keep up with these changes in the world of work to adequately address the resulting new occupational risks and any effects on workers' health [12].

2. New Forms of Work: Overview

Over the last decade, Industry 4.0 has expanded to include new forms of work. This term describes an innovative concept relevant to implementing and integrating novel high-tech strategies and tools in production systems to "digitally connect everything in and around a manufacturing operation in a highly integrated value" [13, 14].

The aim of Industry 4.0 is to achieve high productivity and flexibility by transforming industrial manufacturing processes through greater automation and computerization. Available evidence suggests that Industry 4.0 might be associated with several OSH issues and concerns, such as work-related psychosocial hazards and privacy invasion [14]. The spread of Industry 4.0 also has implications for decent work. For example, regarding *employment creation*, automation, and computerization are, on the one hand, eliminating some low-skilled and more repetitive jobs and, on the other hand, necessitating new jobs that require specific skills related to the continuous technological evolution of Industry 4.0. In this context, the role of OSH is fundamental to guarantee a transition that protects workers' health as much as possible. Indeed, while eliminating repetitive and low-skilled jobs can reduce the accident phenomena related to this type of work, Industry 4.0 likely has a high psychosocial impact on many workers and involves the acquisition of specific skills, which bring new related hazards and risks [14].

The European Union has begun to address the limits of Industry 4.0 by proposing the transition to Industry 5.0, which is more sustainable, human-centric, and resilient [15]. Industry 5.0 places the well-being of humans at the center of production systems to go beyond employment and growth to the robust delivery of prosperity for the sustainable development of all humanity [16]. Thus, Industry 5.0 also supports *social protection*. Precisely for this reason, it is necessary to guarantee *workers' rights* by developing policies and guidelines to ensure workers' protection when the Industry 4.0 paradigm is implemented. Furthermore, to provide *social dialogue*, it is crucial to facilitate workers' active workplace participation in the processes used to identify, evaluate, and manage the new hazards introduced by Industry 4.0, thereby enacting a bottom-up approach and considering all possible stakeholders.

In conclusion, innovative technologies and new forms of work can not only promote but also undermine the future of decent work. Accordingly, all involved stakeholders (i.e., practitioners, researchers, advocates, policymakers, governments, and educators) need to take concerted actions to critically identify OSH challenges related to decent work. Active policies, analysis methodologies, intervention strategies, and operational tools (within OSH's competence) capable of facilitating the realization of decent work should be implemented through an integrated and multidisciplinary approach. To do so, OSH professionals' perspectives and expertise

should be considered in decision-making, leading to developing policies that will fully realize decent work.

2.1. Innovative Technologies

Two examples of innovative technologies will be discussed in this paper. In this section engineered nanomaterials (ENMs) will be discussed. Later in the section 3, innovative technology in the transportation sector will be addressed.

An example of new technologies is the introduction of nanotechnologies into the world of work, as exemplified by ENMs. Currently, ENMs are widely developed, produced, and marketed. This situation has inevitably led to increased human exposure, particularly among workers involved in the entire ENM life cycle of development, production, processing, elimination, and recycling [17]. ENMs can be absorbed through various routes (mainly pulmonary and dermal). They can induce various morphological and functional changes, resulting in negative impacts on the nervous, respiratory, cardiovascular, renal, immune, and endocrine systems, as demonstrated in both *in vitro* and *in vivo* studies [18, 19, 20]. Despite these issues, a systematic and comprehensive risk assessment of these potential hazards still needs to be performed [65]. This lack of a risk assessment inevitably impacts the first pillar of decent work. Although the widespread diffusion of ENMs has created and is still offering employment opportunities and nano-enabled job tasks, the issue of *employment creation* cannot be approached only in quantitative terms but also needs to be approached, above all, in qualitative terms. Ensuring decent working conditions that prevent workers' exposure to uncontrolled hazards and risks is necessary.

In the OSH context, the impact of new technologies can be addressed by implementing the precautionary principle, publishing and disseminating best practices and recommendations to evaluate and manage ENMs in workplaces, and guaranteeing *social protection*. This approach can also be used for other new and emerging risks [4]. For example, *workers' rights* can also be guaranteed in the presence of new and emerging risks with uncertainty surrounding their extent and severity through applying prevention and protection measures via engineering and administrative controls and personal protective equipment.

However, ENMs are a considerable challenge in *social dialogue* due to the significant uncertainty about their hazards, risks, and burdens. In this case, OSH professionals can be crucial in facilitating dialogue between social partners, especially by raising awareness and avoiding underestimating the risks. Nevertheless, field research using a participatory approach to engage with stakeholders is needed to identify adequate data communication and transferability strategies. In this context, it is essential to communicate to employers, workers, and government representatives the potential safety and health risks associated with new and emerging hazards in the workplace and to implement practical and innovative training and education programs for employers, workers, and OSH professionals aimed at increasing their knowledge and awareness of ENMs.

2.2. Social Protection in Anticipating New and Emerging Risks

Decent work is fundamental to supporting inclusive and sustainable economic growth and achieving total productivity [21]. However, new technologies and new forms of work have induced significant morphological and functional changes among workers [22-24]. These changes are driven by new and poorly understood physical and chemical risks, which are often also associated with environmental degradation and the use of nanomaterial engineering in production processes [4, 21, 23]. Although these advances can potentially improve working conditions, they pose significant challenges and uncertainty.

Understanding the new hazards introduced by these technologies is crucial to ensuring workers' safety and promoting healthy work environments. ENMs represent a significant concern among these hazards due to their unique properties and the potential for unknown health impacts [25]. Additionally, Industry 4.0 has impacted work organizations, which may increase psychosocial risks and lead to increased injuries and diseases at the interface with

automated devices, introducing a range of emerging physical risks that must be carefully evaluated [26]. Furthermore, the evolving nature of work environments, such as informality and platform work, can cause psychosocial risks that negatively affect workers' mental health and well-being [1].

2.3. Future Directions and Challenges to Ensure Social Protection

Future work should prioritize workers' well-being, with the pillar of social protection playing an indispensable role in this effort [4]. Ensuring workers' safety, health, and overall well-being in rapidly evolving work environments and technologies is a multifaceted challenge that requires robust social protection mechanisms. These mechanisms should encompass OSH research practices to maintain safe working conditions, provide adequate rest periods, and ensure access to essential benefits.

Different contexts present varied challenges. In high-income countries (HICs), the complexities of intersectionality—that is, how various social categorizations (e.g., race, gender, and socioeconomic status) intersect and impact individuals' experiences—present unique challenges [27]. Addressing these intersectional issues ensures workers equitably benefit from the work environment and technology advancements.

In low- and middle-income countries (LMICs), the challenges are more pronounced in terms of vulnerable groups and the widespread impacts of informality [28]. Informal workers, who often lack access to essential social protection and tend to work in hazardous conditions, represent a significant portion of the workforce in these regions. Ensuring their safety and well-being requires specific interventions that address their particular vulnerabilities and the precarious nature of their work [4].

Social protection should evolve to anticipate future work's new and emerging risks. This evolution includes proactively identifying categories of vulnerable workers and specific groups and understanding how variability in worker-technology interactions can affect health and safety [4, 22]. By focusing on these aspects, social protection frameworks can be better equipped to effectively mitigate new and emerging risks.

Mitigating these risks involves a nuanced understanding of how workers interact with new technologies. For example, workers in HICs may face risks related to technology's complexity and rapid evolution. In contrast, workers in LMICs may be more vulnerable to primary safety risks due to a lack of infrastructure and regulatory oversight. Adapting social protection measures to address these diverse needs is crucial to promoting safe and healthy work environments globally.

Additionally, introducing new workplace risks has profound psychosocial implications for workers. Income instability and uncertainty regarding the availability and continuity of work significantly affect mental health. Studies have shown that economic uncertainty can lead to increased psychological distress, anxiety, and depression [29]. Similarly, job insecurity, a predominant issue in many modern work environments, is closely associated with reduced well-being, leading to decreased job satisfaction and increased absenteeism and turnover rates [30]. Moreover, job insecurity can exacerbate psychosomatic complaints, such as physical tension and other stress-related symptoms, further affecting workers' overall health and productivity.

2.4. Recommendations Regarding Social Protection

How can social protection practitioners and advocates anticipate the unknown effects of new risks and damages? The following discussion addresses some strategies for predicting and mitigating these effects.

2.4.1. Development of Transdisciplinary Skills and Training

One crucial strategy involves the development of transdisciplinary skills and training programs. These initiatives should equip workers and managers with the knowledge and skills to anticipate and address poorly understood risks. By fostering a holistic understanding of potential hazards, such training can enhance workers' ability to navigate complex work

environments safely. Such training should address the intricate interplay of workers' physical, chemical, and psychosocial risks, promoting a comprehensive understanding of workplace safety and health [31, 32].

2.4.2. Identification of Vulnerable Worker Categories

As another strategy, it is imperative to identify and support vulnerable worker categories and specific groups that may be disproportionately affected by new risks. Such groups include low-wage, informal, older, and women, who often face unique challenges adapting to new technologies and working conditions. Tailored social protection measures can help mitigate the impacts on these groups [4].

2.4.3. Understanding the Variability in Worker–Technology Interactions

The following strategy involves deeply understanding how different workers interact with new technologies. It consists in studying the variability in these interactions to develop targeted interventions that ensure the safe and effective use of new technologies across diverse work environments [33].

2.4.4. Expanded Coverage Network

The final strategy involves expanding OSH's coverage to include workers in the informal sector. Informal workers often lack access to basic social protection and are particularly vulnerable to new risks. By extending coverage and benefits to this workforce segment, social protection systems can provide a safety net supporting workers' health, well-being, and economic stability [34, 35].

3. An Example of an Innovative Technology: Artificial Intelligence

3.1. "Cobots" and the Rights of Workers

Artificial intelligence (AI) is making sweeping inroads in the workforce, as evidenced most recently by the extensive use of large language models, including generative AI. While AI creates tangible benefits for workers, there are also emerging physical and psychosocial risks to a safe, healthy, decent working environment. A recent literature review on workers and workplace AI highlighted four areas: (i) can workplace AI augment workers' abilities? (ii) can workers' distrust in AI due to their concern that it will replace their jobs be addressed? (iii) will the loss of noncritical skills impact workers' performance on the job? and (iv) can the teaming of AI and workers be implemented successfully (what we refer to as human-robot teaming, or "cobots") [36]? Below, we describe how these issues relate to a safe, healthy, and decent workplace, focusing on the transportation industry.

3.2. The Benefits of AI: The Example of the Transportation Sector

In the transportation sector, AI can benefit operators' safety, regardless of whether an operator is driving a passenger car, a transit bus, a plane, or a truck. For example, ride-hailing "gig" workers typically drive vehicles with advanced driver assistance systems. The safety benefits of two such systems—automatic emergency braking and lane departure warnings—have been shown conclusively to save lives [37, 38]. Additionally, just as passenger car drivers have been shown to benefit from backup cameras, so too have heavy equipment operators [39].

AI also has benefits for workers' health in this sector. As an example of how AI can improve transportation workers' health, consider parking decisions for commercial motor vehicle (CMV) drivers. The American Trucking Research Institute's recent survey ("Critical Issues in the Trucking Industry") rated truck parking as the second-highest concern among CMV drivers and the eighth-highest motor carrier concern [40]. AI and machine vision are already used to help drivers find parking locations in seaports [41]. Phone applications are being developed to help CMV drivers locate parking destinations that allow them to meet hours-of-service requirements, include amenities that meet their needs, and are safe and easily accessible. Indeed, according to the National Transportation Safety Board, fatigue is the likely cause of more than half of all truck crashes that result

in a driver's death [42]. Thus, the ability to find safe and accessible parking efficiently is a priority for the Federal Motor Carrier Safety Administration.

Finally, AI is being used to increase decency in the transportation sector. For example, inspection programs for CMVs should be considered. The purpose of regular truck inspections is to ensure trucks are safe for people to continue operating them. However, like other scenarios in which trained inspectors and law enforcement officers interact with the public, inspections may be subject to biases. Specifically, past research has indicated that implicit biases play a role in police inspections and enforcement actions for motor vehicles [43]. AI could reduce these biases, especially for inspections centered on the condition of truck tires since it is challenging to decide how severe the cut and mechanical separations are on various types of tires [44].

3.3. Trust and AI

Workers' distrust of AI due to potential job loss has been identified as a serious problem [36]. This problem can be exacerbated through over- or under-trust in the actual functions of AI. Both situations can impact workers' safety. In the transportation sector, this problem is most evident in vehicles described as self-driving. A recent field experiment demonstrated the lethal consequences of over-trust in these vehicles [45]. Drivers navigated a 30-mile course with a Level 2 vehicle (i.e., a car with at least two primary functions automated). Drivers were given both an attention reminder and a hands-on-wheel reminder.

Additionally, the drivers were shown videos regarding risk scenarios, including a video showing a car starting to depart from the roadway, which the driver needs to steer back before letting the function resume. Finally, the drivers were told that the automation does not detect obstacles in the roadway, so they must brake and/or steer away from obstacles and then let the function resume control. During the experiment, a dummy car or trash bag was placed along the roadway without informing the test drivers. The results were unexpected as even after the extensive warnings about the limitations of the automation, one out of every three drivers hit the stationary car or trash bag.

Under-trust in AI can be problematic if operators deactivate warnings to decrease safety-critical events. In transportation, lane departure warnings are one example. Because lane departure warnings are frequently false positives, drivers often deactivate them. In one study, only 45% of vehicles with lane departure warnings had these systems activated [46]. However, at least for heavy trucks in the United States, roadway departures account for 35% of all crashes.

3.4. Skill Loss

By design, AI complements and sometimes replaces workers' skills. This practice can compromise safety in ways that are not predictable but can have major consequences. As AI performs more aspects of a task, the focal worker is left with only high-level situational awareness of what might happen. However, if some lower-order process within the task fails, real problems can occur—something that has been researched extensively in aviation [47]. This issue is especially problematic if the worker has lost the ability to perform the skill automatically and instead has to fall back on the knowledge of how the skill is performed [48]. In transportation, such situations may arise with drivers of electric vehicles. Electric vehicles have a one-pedal operation, which means the accelerator pedal can function as a typical accelerator and a brake to slow the car rapidly, just as typical braking would. One-pedal operation is especially useful in electric buses because it further increases energy efficiency by managing the regenerative braking operation [49]. From a human factors perspective, when returning to driving a two-pedal internal combustion engine vehicle, operators of one-pedal electric vehicles are likely to forget to brake in an emergency and release the accelerator. Although this has not been studied formally, one-pedal electric vehicle operation in transportation could make currently unlikely crashes much more likely.

3.5. Cobots: Human-Robot Teaming

Next, consider successful teaming—in our case, successful cobots. A 2023 article in *Harvard Business Review* argues that three things mark

high-performing teams: a shared understanding of each other's roles, psychological safety or trust, and prosocial service or, in this case, shared fate [50]. First, for a common understanding, every team member should understand how their expertise and job duties contribute to the bigger picture (i.e., to the team's and respective organization's performance). Cobot vehicles (i.e., vehicles with driving automation systems) do not have this capacity. Most drivers do not understand how their expertise contributes to the expertise of the automation—for example, that the automation cannot "see" a stopped vehicle. Currently, automation, at least as embodied in driver state monitoring systems, does not truly understand how its expertise is needed to maintain drivers' attention—for example, drivers need to be warned when a hazard appears, and they are not attending to it. Second, psychological safety occurs when team members feel safe expressing themselves, speaking up when they have questions or concerns, disagreeing with each other, making mistakes, and taking interpersonal risks. Again, this is not the case with the current cobot paradigm. However, research on crew resource management in the airline industry indicates that the pilot and copilot need to be a team and build trust so the copilot can let the pilot know when they think there is an error the pilot has not recognized. The pilot has faith in the copilot and pays attention. In the context of cobot vehicles, warning systems need to learn from drivers when alarms are false, and drivers need to learn why warning systems are giving particular warnings. Currently, drivers provide no information to warning systems, and warning systems provide no information beyond warnings to drivers. However, when such information is given, this communication can lead to psychological safety. Large language models could be helpful here for learning from and teaching drivers. Finally, prosocial service in terms of a shared fate involves a deeper level of trust on the part of humans. The Trolley problem is a good example here. In one version, a runaway trolley is on course to collide with and kill several people (traditionally five) down the track. Still, a driver or bystander can intervene and divert the vehicle to kill just one person on a different track. Regarding prosocial service, the driver needs to know their response and how the automation would implement that response.

3.6. Summary of AI in the Transportation Sector

In summary, workers need to (as much as possible) be fully capable of performing all of the technical and conceptual tasks involved in their jobs, especially those aspects that are performed infrequently (i.e., those performed primarily by AI) and could cause critical safety events. If workers cannot perform these tasks (i.e., there is no true teaming with AI), the safety and health risks are considerable, as detailed above. Here, very briefly, we want to address how AI could lead to a workplace that is not decent for workers if AI is introduced without care.

The most considerable risk arises in human resources and performance evaluations. One example outside of transportation is the Horizon Post Office scandal. In that case, prejudicial AI systems wrongly identified and harassed people as potentially having been involved in one or more illegal actions [51]. In transportation, biases could be introduced in the hiring process, performance evaluations, and, potentially, CMV inspections [52]. Thus, individuals involved in hiring and performance evaluation processes must be aware of the potential biases in seemingly unbiased algorithms.

4. Decent Work and Aging Workers

Another determinant of decent work is aging. Like new forms of work and innovative technologies, aging is critical in realizing decent work.

4.1. Early Aging at Work

The definition of an aging worker is generally based on the period when significant changes occur in relevant work-related functions during a person's work life. While the ages of 40 or 45 were typically used as benchmarks for considering a worker to be older in the past [53], age references are currently on the rise to 50, 55, or 60, reflecting not only the aging of the labor force but also the increase in the legal retirement age [54].

Biological aging is a dynamic and progressive process characterized by morphological, functional, biochemical, and psychological changes. These modifications lead to the progressive loss of the ability to adapt to one's environment, causing greater vulnerability, increased incidence of pathological processes, and a gradual decrease in functional capacity [55].

As workers get older, interindividual variability increases, so it becomes possible to identify people with functional and work-ability limitations at an early age. In many cases, some of these processes of functional incapacity are related to occupational exposure [53, 56].

4.2. Changes During the Aging Process

Negative changes during the biological aging process may include increased morbidity burden, decreased functional capacity, reduced musculoskeletal capacity, lowered cardiovascular and respiratory efficiency, reduced motor functions, reduced sensory functions (visual and auditory acuity), increased sleep disorders, the need for more recovery time between shifts/workdays, diminished cognitive capacity for information processing and the memory system, and decreased competence to master new types of mental tasks and new concepts [57, 58].

Positive changes can also occur, including enhanced critical thinking, judgment, and decision-making capacity; increased ability to understand the whole; more empirical knowledge, life experience, and wisdom; increased ability to solve complex problems based on experience, knowledge, practice, and diligence; commitment to quality, health, and safety at work; strong understanding of one's company and loyalty/commitment to one's institution; lower turnover and lower absenteeism; strong language and communication skills; independence; increased responsibility and social competence; leadership skills; and greater motivation to learn [53, 56-58]. All of these changes can influence individuals' work ability and functional aging at work, both positively and negatively.

4.3. Constraints to Decent Work

The global population is aging, which demands and will continue to demand longer working lives. To enable people to remain at work, decent work must support workers to maintain employment as they age. However, participation in work requires workers to be sufficiently healthy. Disability from work occurs not only from the aging process but also through exposure to adverse work environments [59, 60].

Thus, using a system thinking lens, analyzing the micro (individual), meso (work), and macro (societal) impacts on individuals' health outcomes provides a way to consider potential actions to enable sustained working lives for all workers, including those who are older [8, 57, 61-63]. This perspective is crucial when looking at changes in the global economy and its enormous impact on labor markets. It is vital to strengthen positive early employment trajectories and explore the influence of contextual factors on individuals' working life experiences starting at a young age [64].

4.4. Actions for Healthy Aging at Work

As discussed earlier, the OSH framework for decent work proposes four pillars: employment creation, social protection, worker rights, and social dialogue. It also introduces eight determinants that intersect with each pillar, including new technologies and new forms of work, demographics (aging and gender), globalization, informal work, migration, pandemics, OSH policies, and climate change [4].

One challenge for the OSH community working to promote sustained employment is developing practical actions to support longer working lives. Therefore, actions must be taken across the life course, and a systems model must be utilized to maximize their effectiveness.

Actions to promote workers' capacity, prevent early functional aging at work, and treat and support workers who are already compromised and those with disabilities and limitations cannot be limited to older workers [57, 62]. These actions must be implemented at three levels—the micro, meso, and macro

levels. Below, we briefly highlight proposed actions at each level.

At the micro (worker) level, a systems analysis of the drivers of sustainable employment is needed, with a particular focus on older workers. Moreover, longitudinal research is required to examine the relevant influences related to sustainable working conditions, to investigate workers' needs throughout their working lives, and to identify critical periods. Comprehensive risk assessments of work environments also need to include coverage of physical and psychosocial hazards to ensure prevention strategies can be implemented early. Further, older workers need to be engaged in planning their jobs to provide a good match between their capacities and their job requirements and to ensure disabled yet productive aging workers are integrated into the workplace. Finally, work systems need to be analyzed to make sure they consider the limitations and capabilities of workers as they age.

At the meso (workplace) level, new technologies must be implemented to improve the coupling between humans and work systems and increase the integration of disabled and older workers. Further research is needed to investigate the impact of automation on the creation of high-quality jobs aimed at preventing disabilities and to explore virtual reality to promote new forms of work for disabled and aging workers. Finally, the systems design perspective needs to consider workers' mental health, the potentials and pitfalls of new challenges need to be further explored, and work systems that integrate human factors and ergonomic principles need to be promoted.

At the macro (social) level, organizations need more guidance on creating sustainable working conditions by improving their management of physical and psychosocial hazards. They also need support to ensure disability protection for productive aging workers and to ensure disability protection throughout individuals' entire working lives. Further, organizations must promote lifelong learning programs to empower workers and disseminate information about labor rights and social resources. They can also support initiatives by workers' representatives and encourage and participate in forums with government representatives, employers, and civil societies. Additionally, the OSH framework can be used to identify and implement appropriate actions to support the creation of sustainable employment across the life course to encourage and enable older workers to remain at work [33].

Overall, researchers, practitioners, advocates, policymakers, and governments need to take action to address all system levels—micro, meso, and macro—to ensure an appropriately targeted and comprehensive set of strategies is developed and implemented.

5. Conclusion

This paper illustrates the opportunities for OSH to address two determinants of decent work: innovative technologies/new forms of work and aging. In both cases, OSH resonates with the pillars of decent work to protect workers and enhance their opportunities to achieve decent work.

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